STANDARDS DEVELOPMENT BRANCH OMOE
3 6936 00000 2892

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact Service Ontario Publications at copyright@ontario.ca

TD
196.A75
P64
1984
pt.1

POLYAROMATIC HYDROCARBONS

AN INFORMATION UPDATE

PART I

A Summary of Selected References

Prepared for:

Ontario Ministry of the Environment

September, 1984

MENON ENGINEERING INCORPORATED

ACKNOWLEDGEMENT

The Public Services Section of the Science and Medicine Library; University of Toronto performed the searches of all the databases other than FRSS and Cesars. Searches of these two databases were performed by the Ontario Ministry of the Environment. Amost all of the references, other than NTIS reports were obtained from Canada Institute for Scientific and Technical Information (CISTI), Ottawa or the Science and Medicine Library of the University of Toronto. NTIS reports were obtained from NTIS, U.S.A. This part I of the report was type written by the Berkeley Typing and Secretarial Centre.

Errors

The Part I is in first draft form and contains handwritten corrections.

CONTENTS

Page No.

Introduction 1

Emissions 2

Ambient Concentrations 152

Environmental Fate 207

Toxicity 230

Risk Analysis 350

Standards 352

References 353

INTRODUCTION

This is the Part I of the project for the information update of PAHs. Selected references are summarized here. Part II is a bibliography and is prepared from searches of selected computer databases. The databases are indicated in Part II. Chosen few references from computer search results; PAH symposid publications; the handbook of polycyclic aromatic hydrocarbons; environmental health perspectives. Information from selected fields from search results of computer databases toxicology databank and cesar form the sources of information for summarisation. In addition, Chemical Abstracts for CAS Numbers and ACGIH 1981 TLVS for TLVS were also persued. In order to keep the project within its scope, due to inability to obtain some references, and due to longer than expected time in searching the computer databases, some references which otherwise would have been summarised, have been not selected for summarisation; some very recent references inclusive.

Information is summarised in six different areas, which are the following: Emissions; Ambient Concentrations; Environmental Fate; Toxicology; Risk Analysis and Standards. Information presented in the areas, Risk Analysis and Standards, are almost nil, As almost no references have been found for the desired information in these areas. Data presentations in Emissions and Ambient Concentrations and part of the data presented in toxicology area are in table forms. Few references from the information presented as progress reports have been omitted, and some additional references are included in preparation of this final report.

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Acenaphthene	83-32-9	Wood heaters.		-	53
		Heater 1; nonbaffled airtight circulator	0.0049 gm/kg wood		
		Nonbaffled airtight catalytic radiant unit			
		Retrofit,add-on catalytic combustor added to heater 1	0.00 79 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0056 cm/kg wood		
		Airtight unit with secondary combustion provisions	0.0024 gm/kg wood		
		Petroleum ~~wood~~ asphalts; simulated atmospheric and lighting conditions	Identified	-	46
		Wood stove; varying ~~brown~~ modes - side draft; up draft, downdraft; high turbulence draft. Total wood burned 6.33 to 6.79 kg. Seasoned oak (low-high)· particulates	0.12-0.60 mg.	-	129
		gascons	18-58 mg		
		Green prime (side-draft)· particulates	0.27 mg		
		gascons	89 mg		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Acenaphthene	83-32-9	Power plant boilers Boiler fired by heavy fuel oil without flue gas cleaning system	Less than 0.5 $\overset{\mu}{\mathrm{n}}\mathrm{g/m}^3$	-	21
		Boiler fired by pulverised coal equipped with electrostatic precipitator	Less than 1 $\overset{\mu}{\mathrm{n}}\mathrm{g/m}^3$	-	21
		Boiler fired by coal; equipped with baghouse filter for cleaning flue gas	Less than 5 $\overset{\mu}{\mathrm{n}}\mathrm{g/m}^3$	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter	270 $\overset{\mu}{\mathrm{n}}\mathrm{g/m}^3$	-	21
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts).		-	32
		Toluene	0.5	-	31
		Toluene/Heptane	0.48	-	31
		Heptane	1.75	-	31
		In ~~common~~ paper/ng/ sheet)	1.8	_	113
		Automobile exhaust Cigarette smoke;	Identified	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Acenaphthylene	208-96-8	Laboratory coal gasi- (blends of different types of coals)	66 ng/J~~une~~	-	28
		Wood heaters		-	53
		Heater 1; a nonbaffled airtight circulator	0.0246 gm/kg wood		
		A nonbaffled airtight catalytic radiant unit	0.0044 gm/kg wood		
		Retrofit add on catalytic combustor added to heater 1	0.0150 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst	0.0145 gm/kg wood		
		Air tight unit with secondary combustion provisions.	0.0071 gm/kg wood		
		Pilot plant coal gasification gas; water soluble components; subbituminous coal; peat and lignite coal; as biphe~~m~~nylene or acenaphthylene.	Identified	-	128
		Pilot plant coal gasification; base-neutral water extract of raw gas		-	128
		subbituminous coal	4.0 mg/1		
		Lignite coal	4.6 mg/1		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Acenaphthylene	208-96-8	Power Plant Boilers			
		Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5 $\mu g/m^3$	-	21
		Boiler fired by pulverised coal equipped with electrostatic precipitator	Less than 1 $\mu g/m^3$	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas	Less than 5 $\mu g/m^3$	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter	1400 $\mu g/m^3$	-	21
		Coal liquefaction pilot plant, U.S.A.	-	-	15
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts).			
		Toluene	11	-	31
		Toluene/Heptane	12.64	-	31
		Heptane	21.50	-	31

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Acenaphthylene	208-96-8	Airtight woodburning stove; seasoned oak; two sizes; two burn rates; polar fraction; condensable portion of stack gases. two samples sets.	0.1462-0.4994 and 0.0822-1.9159 mg/kg wood	-	73
		Wood stove; varying ~~brown~~ burn modes - sidedraft; updraft; down draft; high turbulence draft. Total wood burned 6.33 to 6.79 kg		-	129
		Seasoned oak (low-high)			
		particulates	0.06-0.27 mg		
		gaseous	1.9-26 ~~n~~mg		
		Green ~~prime~~ pine (sidedraft)			
		particulates	0.06 mg		
		gaseous	7.3 mg		
		Wood stove with a catalytic combustor; condensable fraction		-	75
		Before the combustor	40 ~~n~~μg/ of organics		
		After the combustor	5 ~~n~~μg/of organics		
		Coal combustion; residential bituminous coal, subbitumnous coal; washed, unwashed blends	0.144/ lb/ton	-	130
		In carbon paper (~~n~~μg/ sheet)	9.6		113

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Alkyl napathalenes	-	Airtight wood burning stove; seasoned oak; two sizes; two burn rates, polar fraction; condensable portion of stock gases.		-	73
		as C_3-naphthalene low-high	0.0967- 0.2073 and 0.0317- 0.0364 mg/kg wood		
		As C_4-naphthalene low-high	0.0321- 0.0533 and 0.0127- 0.0533 and 0.0127- 0.0271 mg/kg wood		
		as C_5-naphthalene	0.1520 mg/kg wood		
		Coal combustion; reside ntial; bituminius coal, subbituminous coal; washed, unwashed, blends		-	130
		C_3-a~~ue~~lkylnaphthalen~~u~~es	0.176 lb/ton		
		C_4-alkylnaphthalenes	0.056 lb/ton		
		C_5-alkylnaphthalenes	0.016 lb/ton		
		Wood combustion; non-baffled stove burning ~~sectioned~~ seasoned oak; low/high altitude tests.		-	79
		As C_2-alkylnaphthalene	0.0011 g/kg		
		Lignite fired utility boilers: Ambient Severity reactor (ASF) defined as ratio of maximum ground level concentration calculated to the level at which a potential enviornmental hazard exists.			

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Alkyl naphthalenes		Pulverized dry bottom:			
		Emission Factor	0.0033 ng/J		
		ASF	0.0001 ng/J		
		Cyclone equipped:			
		Emission factor	0.00034 ng/J		
		ASF	<0.0001 ng/J		
		Stokers:			
		Emission Factor	0.0032 ng/J		
		ASF	<0.0001		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Woodstove; varying ~~brown~~ burn modes - side draft, updraft, down draft, high turbulence draft. Total wood burned 6.33 to 6.79 kg. Seasoned Oak (low-high) Particulates Gaseous ~~Gaben prime~~ Green pine (sidedraft) Particulates Gaseous	0.08-0.43 mg 2.2-18 mg 0.35 mg 19 mg		
		Wood Stove with a catalytic combustor; condensable fraction Before the combustor After the combustor As C_1-phenanthrenes/anthracene Before the combustor After the combustor	224 μg/ of organics 100 μg/of organics 38 μg/of organics 14 μg/of organics	-	75
		Coal combustion; residential bituminous coal, subbituminous coal; washed, unwashed, blends as anthracene and phenanthrenes	0.058 lb/ton	–	130
		Wood combusion; non-baffled stove; burning seasoned oak; low/high altitude tests. As anthracene and phenanthnene low altitude test high altitude test	0.0618 g/kg 0.0100 g/kg	-	79
		Pulverized coal fired laboratory boiler; equipped with baghouse filter; as anthracene/phenanthrene low-high range (6 tests)	12-110 μg/m^3	-	98

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Low sulfur coal wall fired boiler, equipped with baghouse filter. As anthracene and phenanthrene			
		Baghouse inlet	1.5, 4.6 ~~n~~μg/m^3		
		Baghouse outlet	1.7, 5, 14.8 ~~n~~μg/m^3		
		Electric power plant boiler, medium sulfur eastern ~~wall~~ coal tangentially fired, equipped with electrostatic precipitator; U.S.A. (anthracene/phenanthrene)		-	98
		Amount in unknown sample size; low-high ranges, 3 test results	0.0-372.3 ~~ng~~ μg 0.2 - 190.4 μg 7.0 - 635.1 ~~ng~~ μg		
		6 test results	1.0-37.5 ~~n~~μg/m^3		
		Open burning; refuse burning ~~hot water~~ Hot Water boiler; combustion of wood and peat; relative to benzo(ghi) perylene	Identified	-	99
		wood	4.2		
		peat	3.7		
		Laboratoary coal gasification; (blends of different coals)	3.1 ng/J	-	28
		Coal combustion	0.46, 0.5 X10^{-5} ng/J coal energy	-	28
		Wood stoves burning wood including oak, maple and pine, Canada	5-276 ~~n~~μg/kg fuel	-	55
		Woodburning furnace emissions, Canada	10-140 ~~n~~μg/gm particulates	-	55

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Wood heaters: (as phenanthrene and anthracene)			
		Heater 1 - nonbaffled airtight circulator	0.0412 gm/kg wood		
		Nonbaffled airtight catalytic radiant heater.	0.0103 gm/kg wood		
		Retrofit, add on catalytic combustor added to heater 1.	0.0372 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst	0.0297 gm/kg wood		
		Airtight Unit with secondary combustion provisions.	0.0140 gm/kg wood		
		Power plant; laboratory coal fired fluidized bed; range; temperature variation at the high value.	70-124000 ng/m^3	-	51
		Petroleum road asphalts; simulated atmospheric and lighting conditions (two samples)	481 and 168 ng/m^3	-	46
		Pilot plant coal gasification gas: water soluble components, subbituminous coal; peat and lignite coal (or phenantenene).	Identified	-	128
		Pilot plant coal gasification; base-neutral water extract of Raw gas;		-	128
		Subbituminous coal	9.2 mg/1		
		Lignite coal	9.2 mg/1		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Airtight wood burning stove. Seasoned oak; two sizes; two burner rates as phenanthrene/ anthracene.	0.88 and 2.3 mg/kg wood	-	73
		as C1 phenanthrenes/ anthracenes	0.42 and 0.18 ~~0.18~~ mg/kg wood		
		As C_2-phenamthrene/ anthracene	0.11 and 0.04 mg/kg wood		
		As C_3-Phenanthrenes/ anthracenes	0.2 and 0.3 mg/kg wood		
		Baffled stove; seasoned oak; As Anthracene/ phenanthrene.	74.5 mg/ kg wood		73
		AsC_1-phenanthrenes/ anthracenes	21.1 mg/kg wood		
		As C_2-phenanthrenes/ anthracenes	4.0 mg/kg Wood		
		As cyclopentaphenanthrenes/anthracenes	3.2 mg/kg wood		
		Power Plant Boilers. Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5 µg/m^3		21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 0.2 µg/m^3		21
		Boiler fired by coal; equipped with baghouse filter for cleaning flue gas.	Less than 0.2 µg/m^3		
		Boiler fired by coal; Inefficient combustion equipped with baghouse filter	100 µg/m^3		21
		Diesel Particulate Extract (Phenanthrenes and anthracenes)	1.1 ppb		10
		Ferroalloy Plants. ~~coal~~	—	—	15
		Coal liquefaction pilot plant, USA	—	—	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Oil fired central heating system; light oil; oil burner.	0.3 ng/kg fuel	–	12
		Diesel Engine; ECE Test.	6 ng/liter fuel	–	12
		Extract of soot collected from flames; benzene-air mixture fuel; % extractable fraction, range in 40°C to 200°C.	97-2.3		31
		Solvent extract of emissions collected from flames fueled by hydrocarbons)-air mixture (as % amounts).			31
		Toluene	4.5	–	31
		Toluene/Heptane	3.51	–	31
		Heptane	9.12	–	31
		Pilot plant foundry air; Finland.	Detected	–	29
		Iron foundries; anthracene particulate matter; Finland.	Detected	–	29
		Pyrolysis of iron foundry molding sands; Finland, (as % 10 PAHS two samples).	5% and 12%	-	29
		Wood combustion (as anthracene and phenanthrene).		-	26
		Zero clearance fire place			
		Seasoned oak	0.0082gm/kg wood	-	
		Green pine	0.0069gm/kg wood	-	
		Airtight baffled stove:			
		seasoned oak	0.0745gm/kg wood	-	
		Airtight nonbaffled stove, seasoned oak	0.0618 gm/kg wood	–	
		Green pine	0.1034gm/kg Wood	–	
		Ferroy alloy furnaces			
		Open silicon metal gas phase Emissions	172μg/m^3 113gms/hr	-	108
		Covered ferrosilicon secondary ~~firm~~ fume gas phase emissions	57ng/m^3 37gms/hr		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Foundries, Ontario			109
		Personal samples, maximum	$0.09 \mu g/m^3$		
		Air samples, maximum	$< 0.008 \mu g/m^3$		
		Residential Wood Stove ($\mu g/kg$ dry fuel burned)			
		Birch: normal combustion	822		
		Birch: starved combustion	1654		
		Spruce: normal combustion	834		
		Spruce: starved combustion	8390		
		Residential charcoal stove, to be reduced by a factor of 3 to 4 for comparison with wood ($\mu g/kg$ dry fuel burned)	3.9		
		In carbon paper ($\mu g/$sheet)	3.9		113

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Anthracene -9,10 dione	84-65-1	1978 Oldsmobile diesel engine particulates extract	identified	-	33
		Airtight wood burning stove, seasoned oak, condensible fraction of stack gas, polar fraction	0.4349 mg/kg wood	-	73

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(c) acridine	225-51-4	Domestic ~~oval~~ coal combustion stack effluent	$15\overset{m}{\text{n}}\text{g}/1000\text{m}^3$	-	137
		Petroleum refinery incinerator effluents	18 and 60 mg per 1000m^3	-	137
		Air polluted with coal tar pitch	0.12 mg per 1000m^3 in air		
		Coal tar pitch volatiles; 20 Coke plants	Less than $2\overset{\mu}{\text{m}}\text{g}$	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Anthracene	56-55-3	Pilot plant coal gasification gas, water soluble components, subbituminous coal	Identified	-	128
		Pilot plant coal gasification, base-neutral, water extract of raw gas subbituminous coal lignite coal	 5.4mg/1 1.9mg/1	-	128
		Airtight wood stove, seasoned oak; two sizes, two burn rates, as benz(a) anthracene/ chrysene	0.44 and 1.35mg/kg wood	-	73
		Baffled stove, seasoned oak, as benz(a) anthracene/chrysene	12.5mg/kg wood	-	73
		Airtight wood burning stove, seasoned oak, two sizes; two burn rates, polar fraction, condensable fraction of stack ~~jans~~ gases.	0.1508 0.4769 mg/kg wood	-	73
		Wood stove, varying burn modes; side draft, updraft, down draft, high turbulance draft. Total wood burned 6.33 to 6.79 kg.		-	129
		Seasoned oak (low-high) particula~~r~~tes gaseous	 0.16-5.9mg 1.0-13 mg		
		Laboratory coal gasification (blends of different coals)(benzo(a) anthracene and chrysene)	23ng/J	-	28
		Coal combustion	2.4, 15.4 x 10^{-5} ~~-6~~/5 ~~0mk~~ Joule Coal energy	-	28

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Anthracene	56-55-3	Wood stoves burning wood including oak, maple and pine, Canada.	8-157μg/kg fuel	-	55
		Wood burning furnace emissions, Canada	trace-3.0μg/gm particulates.	-	55
		Woodheaters (as chrysene/benzo(a) anthracene)		-	53
		Heater 1-nonbaffled airtight circulator	0.0102gm/kg wood		
		Nonbaffled airtight catalytic radiant heater.	0.0013gm/kg wood		
		Retrofit addon catalytic combustor added to heater 1.	0.0075gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0049gm/kg wood		
		Airtight unit with secondary combustion prvisions.	0.0018gm/kg wood		
		Wood combustion	480μg/kg wood 560μg/kg wood	-	59
		Diesel Particulate Extract	0.95ppb	-	10
		Vehicles:			
		Fiat 126, ECE test	25μg/km	-	7
		Fiat 126, ECE test	50μg/km	-	7
		Japanese, City mode driving cycle, mean of 5 vehicles.	9μg/km	-	7
		3 types of vehicles, FTP test low-high ~~high low~~ hot start, range,	3-15μg/km	-	7
		3 types of vehicles, FTP test, cold start, low-high range.	8-25μg/km	-	7
		Vehicle (1969) FIP test	38μg/km	-	7
		Vehicle (1970) FTP test	20μg/km	-	7
		Vehicle (1972) FTP test	5μg/km	-	7
		Gasoline vehicle, FTP test, cold start	6.2μg/km	-	7
		Gaoline - catalyst vehicle, FTP test cold start	0.06μg/km	-	7

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) anthracene	56-55-3	Gasoline -15% methanol FTP test, cold start.	2.0 μg/km	-	7
		Diesel vehicle, FTP test, cold start.	34μg/km	-	7
		Japanese vehicle, new oil, city driving cycle.	11μg/km	-	7
		Japanese vehicle, used oil, city driving cycle.	19μg/km	-	7
		Coal liquefaction pilot plant, USA	-	-	15
		Hand stoked residential stove, coal briquettes combustion (flue gas).	45μg/m^3	-	12
		Oil fired central heating systems, light oil; Oil burner	250ng/kg fuel	-	12
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		1978 Oldsmobile engine particulate extract.	identified	-	33
		Solvent extracts of emissions from hydro carbone(s) - air mixture fueled flames. (% amounts)		-	31
		Toluene	0.5	-	31
		Toluene/Heptane	0.16	-	31
		Heptane	0.19	-	31
		Wood combustion (as benz(a) anthracene/ chrysene)		-	26
		Zero clearance fireplace			
		seasoned oak	<0.0014gm/kg wood		
		green pine	0.0014gm/kg wood		
		Airtight baffled stove			
		seasoned oak	0.125gm/kg wood		
		green pine	0.138gm/kg wood		
		Airtight nonbaffled stove			
		seasoned ~~pine~~ oak	0.0076gm/kg wood		
		green pine	0.0371gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Anthracene	56-55-3	Green pine (side draft)			
		particulates	3.0mg		
		gaseous	0.22mg		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends, as chrysene and benz(a)anthracene.	0.014lb/ton	—	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests, as benzo(a)anthracene/chrysene		-	79
		low altitude test	0.0076g/1g		
		high altitude test	0.0023g/kg		
		Refractory cements plant; USA	0.22 to 1.41 $\mu g/m^3$	6/27/79 9/26-27/79	88
		Personal air samples low-high range	0.22-2.41$\mu g/m^3$	9/26-27/79	
		Aluminum plant, Ravenswood, West Virginia, USA range	Not detected to 28.0$\mu g/m^3$	1979	90
		mean	1.7$\mu g/m^3$		
		Aluminum plant, Chalmette, Louisana USA, range, pot room	3.47-4.87$\mu g/m^3$		91
		Range:	0.10-31.81$\mu g/m^3$	4/6-7/78	91
		Background	< 0.14and<0.18 $\mu g/m^3$	4/6-7/78	91
		Asphalt shingles plant, Pittsburgh, California, USA Area samples	6.19 and 1.89$\mu g/m^3$	8/4/77	93
		Electric power plant boiler; medium sulphur eastern wool tangentially fired; equipped with	0.1-3.2kg	-	98
		electrostatic precipitator, USA (as chrysene/benz(a) anthracene)	0.2-45.4kg		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) anthracene	56-55-3	Amount is unknown samples size, low-high ranges, 3 tests results	0.4-119.7 μg		
		Diesel engine, a composite of ten commercial No. 2 diesel fuels.	identified	-	99
		Cars, gasoline fuel·	identified	-	99
		Hot water boiler - combustion of wood and peat		-	99
		relative to benzo(ghi) perylene			
		Wood	3.4		
		Peat	4.7		~~108~~
		Ferroalloy furnaces, Covered silicon metal, gas phase	4 μg/m^3	-	108
		emissions	2gms/hr		
		Foundries, Ontario (as benz(a)anthracene and chrysene)			
		Personal samples, maximum	9.39 μg/m^3	-	109
		Area samples, maximum	22.10 μg/m^3		
		Personal mean range	0.46-1.80 μg/m^3		
		Personal maximum range	0.59-9.39 μg/m^3		
		Area samples, mean	2.90 μg/m^3		
		Foundries, Ontario, varying factors (as benz(a)anthracene and chrysene			
		Range, varying ventilation	0.32-2.06 μg/m^3		
		Season - winter	2.01 μg/m^3		
		- spring	0.77 μg/m^3		
		- summer	0.14 μg/m^3		
		Type: steel	0.81 μg/m^3		
		iron	2.48 μg/m^3		
		non-ferrous	0.07 μg/m^3		
		Ferrons and non-ferrous	0.81 μg/m^3		
		Residential wood stove (μg/kg dry fuel burned)			

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benz(a) anthracene	56-55-3	Birch: normal combustion	476		
		Birch: starved combustion	326		
		Spruce: normal combustion	60		
		Spruce: starved combustion	781		
		In carbon paper (μg/ sheet)	5.5		113
		Coal fly ash, tentative	identified		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
7H-Benz (de) anthracene -7-one	82-05-3	1978 Oldsmobile diesel engine particulates extract	identified	-	33
		Wood combustion wood	500$\overset{\mu}{\text{n}}$g/kg wood	-	59
		coal fly ash, tentative	identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(b) fluoranthene	205-99-2	1978 Oldsmobile diesel engine particulates extract (Benzo fluoranthenes).	identified	-	33
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) -air mixture (as % amounts)		-	31
		Toluene	0.35	-	31
		Toluene/Heptane	0.15	-	31
		Heptane	0.19	-	31
		Pilot plant foundry -air samples as benzofluoranthenes, Finland	detected	-	29
		Iron foundries, airborne particulate matter; Finland as benzofluoranthenes.	detected	-	29
		Wood combustion (as benzofluoranthenes)		-	26
		Zero clearance fireplace			
		Seasoned oak	$<$0.0014gm/kg wood		
		Green pine	0.0016gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0128gm/kg wood		
		Green pine	0.0159gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0112gm/km wood		
		Green pine	0.0141gm/kg wood		
		Laboratory coal gasification (blends of different coal(s)) (Benzo(b and k) fluoranthenes)	0.4ng/J	-	28
		Coal combustion	$<0.007\times10^{-5}$ ng/J coal energy	-	28

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(b) fluoranthene	205-99-2	Fluidized bed coal combustion (3 samples); Benzo (b and K) fluoranthenes)	(0.03;2;6) $\times 10^{-5}$ ng/J	-	28
		Wood heaters: (as benzo(b) fluoranthene/ benzofluoranthene)		-	53
		Heater 1 - nonbaffled airtight circulation	0.0042 ~~0.0102~~ gm/kg wood		
		Nonfabbled airtight catalytic radiant heater	0.0007 gm/kg wood		
		Retrofit add on catalytic combustion added to heater 1	0.0030 ~~0.0075~~ gm/kg wood		
		Baffled airtight catalytic circulator	0.0025 ~~0.0049~~ gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0009 ~~0.0010~~ gm/kg wood		
		Power plant, laboratory coal fired fluidized bed; range, temperature variation at the high value.	18-730ng/m^3	-	51
		Petroleum ~~wood~~ road asphalt, simulated atmospheric and lighting conditions (two samples)	29 and 299ng/m^3	-	46
		Pilot plant coal gasification, base neurtal water extract of raw gas, Subbituminous coal (as benzo(b) fluoranthene/ benzo(k) fluoranthene)	2.08 ~~g/l~~ mg/l	-	128
		Wood stove: Varying burn modes - side draft updraft, downdraft, high turbulence draft. Total wood burned 6.33 to 6.79kg (as benzofluoranthenes)		-	129

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(b) fluoranthene	205-99-2	Seasoned oak (low-high) particulates gaseous Green pine (side draft) particulates gaseous	 0.11-14mg 0.86-17mg 21mg 0.15mg		
		Wood stove with a catalytic combustor, condensable fraction, (as benzo fluoranthenes) Before the combustor After the combustor	 40µg/of organics Below detection limit	-	75
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends as benzofluoranthenes.	0.014 lb/ton	–	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests. low altitude test high altitude test	 0.0112g/kg 0.0021g/kg	-	79
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA (As benzo fluoranthene) Amount in unknown Sample size, low-high ranges, 3 tests results	0.2-1.2ug 0.5-18.7ug 0.2-45.0ug	–	98
		Coke oven ~~baltenics~~ batteries, ratio of benzo fluoranthenes to perylene	2.9,3.6	–	99

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(b) fluoranthene	205-99-2	Petroleum refineries ratio of concentration of benzofluoranthene to benzo(e) pyrene	1.43	1971-72	100
		Residential wood stove (µg/kg dry fuel burned)		-	126
		Birch: normal combustion	1002		
		Birch: starved combustion	179		
		Spruce: normal combustion	108		
		Spruce: starved combustion	1016		
		Residential charcoal stove (µg/kg dry fuel burned) to be reduced by a factor of 3 to 4 for ~~for~~ comparison with wood	0.2		
		Anthracite Coal briquettes, assuming BaP emissions = 100	340	-	3
		Anthracite coal, assuming BaP emissions = 100	1500	—	3
		Brown coal, assuming BaP emissions = 100	300	—	3
		Coal, assuming BaP emissions = 100	700	-	3
		Oil stove, assuming BaP emissions = 100	225	-	3
		Automobile exhaust Condensate, assuming BaP emissions = 100	40	-	3
		Power plant boilers.			21
		Boiler fired by heavy fuel oil without flue gas cleaning system, Benzo (b and k) fluoranthene.	Less than 0.5µg/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator, Benzo(b and k) fluoranthene	less than 0.1µg/m^3	-	21

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(b) fluoranthene	205-99-2	Boiler fired by coal, equipped with baghouse filter for cleaning flue gas. Benzo (b and k) fluoranthene.	Less than 0.07 μg/m^3	-	21
		Boiler fired by coal; inefficient combustion, equipped with baghouse filter (Benzo (b and k) flouranthene).	5~~ng/m~~^{3} 25μg/m^3	-	21
		Gasoline ~~filter~~ vehicle FTP lest, cold start, Benzo (b and k) fluoranthene.	6.8μg/km	-	7
		Gasoline-catalyst vehicle, FTP test, cold start, Benzo (b and k) fluoranthene	0.4μg/km	-	7
		Gasoline -15% methanol FTP lest, cold start, Benzo (b and k) fluoranthene	3.6μg/km	-	7
		Diesel vehicle, FTP test; cold start, Benzo (b and k) fluoranthene.	37μg/km	-	7
		Hand stoked residential stove; coal briquettes, combustion; flue gas.	13.5μg/m^3	-	12
		Oil fired central heating system, light oil (oil burner)	51ng/kg fuel	-	12
		Diesel engine, ECE test.	34ng/liter fuel	-	12
		Engine, gasoline, ECE test	64μg/~~filter~~ liter fuel	-	12
		Gasifier using wastes such as residential garbage and agricultural wastes Benzo (b and k) fluoranthenes.	-	-	15
		In carbone paper (μg/sheet)	9.2	—	113
		Coal fly ash, tentative identified as benzo fluoranthenes	identified	—	121
		Coal fly ash extract as % of extract.	1.41±0.04%	—	121
		Tabacco smoke, 100 cigarettes	0.3~~ng~~ ug	—	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(j) fluoranthene	205-82-3	Wood heaters: (as benzo(b) fluoranthene/ benzofluoranthenes)		-	53
		Heater 1 - nonbaffled airtight circulator	0.0042 ~~0.0102~~gm/kg wood		
		Nonbaffled airtight catalytic radiant heater	0.0007 ~~0.0013~~gm/kg wood		
		Retrofit addon catalytic combustor added to heater 1	0.0030 ~~0.0075~~ gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst	0.0025 ~~0.0049~~gm/kg wood		
		Airtight unit with secondary combustion provisions	0.0009 ~~0.0018~~ gm/kg wood		
		Pilot plant coal gasification gas, water soluble components lignite coal	identified	-	128
		Wood stove, varying burn modes - side draft, updraft, downdraft, high turbulance draft. Total wood burned 6.33 to 6.79 kg (as benzofluoranthenes)		-	129
		Seasoned oak (low-high)			
		particulates	0.11-14mg		
		gaseons	0.86-17mg		
		Green pine (side draft)			
		particulates	21 mg		
		gaseons	0.15mg		
		Hand stoked residential stove, coal briquettes, flue gas.	31μg/m^3	-	12
		Oil fired central heating system, light oil (oil burner) (Benzo (j and k) fluoranthenes)	50ng/kg fuel	-	12

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(j) Fluoranthene	205-82-3	Diesel engine, ECE test (Benzo (j and k) fluoranthenes	23ng/liter fuel	-	12
		Engine, gasoline, ECE test	65μg/liter fuel	-	12
		1978 Oldsmobile diesel engine particulates extract.	identified	-	33
		Pilot plant foundry air samples, Finland as benzofluoranthenes	detected	-	29
		Iron foundries, airborne particulate matter, Finland, as benzofluoranthenes	detected	-	29
		Wood combustion (as benzo fluoranthenes)		-	26
		Zero clearance fireplace			
		Seasoned oak	<0.0014gm/kg wood		
		Green pine	0.0016gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0128gm/kg wood		
		Green pine	0.0159gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0112gm/kg wood		
		Green pine	0.0141gm/kg wood		
		Wood stove with a catalytic combustor, condensable fraction as (benzofluoranthene).		-	75
		Before the combustor	40 μg/of organics		
		After the combustor	Below detection level		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo~~(g)~~(j) fluoranthene	205-82-3	Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends as benzofluoranthenes	0.0141b/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, high/low altitude tests (as benzofluoranthenes) low altitude test high altitude test	 0.0112g/kg 0.0021g/kg	-	79
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA (as benzofluoranthene) Amount in unknown sample size, low-high ranges, 3 test results	0.2-1.2~~ng~~ μg 0.5-18.5~~ng~~ μg 0.2-45.0~~ng~~ μg		
		Coke oven batteries ratio of benzofluoranthenes to perylene	2.9,3.6	—	99
		Petroleum refineries ratio of concentration of benzofluoranthene to benzo(e) pyrene	1.43	1971-72	100
		In carbon paper (μg/sheet)	10.0	—	113
		Coal fly ash, tentative as benzofluoranthenes	identified	—	121
		Coal fly ash extract as % of extract	0.032± 0.006%	—	121
		Air polluted with cigarette smoke, simulated passive smoker conditions	22mg/m^3	-	137
		Petrol engine, West Germany, annual emissions	1850 kg	-	137
		Smoke condensate	0.15-0.2mg/kg	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(k) fluoranthene	207-08-9	Pilot plant foundry Finland Air samples, as benzofluoranthenes	detected	-	29
		Iron foundries, Finland Airbornne particulate matter, as benzofluoranthenes	detected	-	29
		Pyrolysis of iron foundry molding sands, Finland (as % of 10 PAHS, two samples)	1% and 21%	-	29
		Wood combustion: (as benzofluoranthenes)			
		Zero clearance fireplace			
		Seasoned oak	< 0.0014gm/kg wood		
		Green pine	0.0016gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0128gm/kg wood		
		Green pine	0.0159gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0112gm/kg wood		
		Green pine	0.0141gm/kg wood		
		Laboratory coal gasification (blends of different coals) (as benzo (b and k) fluoranthenes)	0.4ng/J	-	28
		Coal combustion	< 0.007×10^{-5} ng/J coal energy	-	28
		Fluidized bed coal combustion, as benzo (b and k) fluoranthenes) (three samples)	(0,03,2,6) x 10^{-5} ng/j	-	28

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo (k) fluoranthene	207-08-9	Wood stoves burning wood including oak, maple and pine; Canada	3-121µg/kg fuel	-	55
		Wood burning furnace emissions; Canada	trace - 5.5µg/gm particulates	-	55
		Woodheaters (as benzo (b) fluoranthene/ benzofluoranthene)		-	53
		Heater 1 - nonbaffled airtight circulator	0.0042 ~~0.0102~~ gm/kg wood		
		Nonbaffled airtight catalytic radiant heater	0.0007 ~~0.0015~~ gm/kg wood		
		Retrofit addon catalytic combustor added to heater 1.	0.0030 ~~0.0075~~ gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst	0.0025 ~~0.0049~~ gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0009 ~~0.0018~~ gm/kg wood		
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value	4-310ng/m^3	-	51
		Petroleum road asphalts simulated atmospheric and lighting conditions.	29ng/m^3	-	46
		Anthracite coal briquettes, assuming BaP emissions = 100	110	—	3
		Anthracite coal, assuming BaP emissions = 100	250	—	3
		Automobile exhaust condensate, assuming BaP emissions = 100	15	-	3
		Oil stove, assuming BaP emissions = 100	60	—	3
		Power Plant Boilers		-	21
		Boiler fired by heavy fuel oil without flue gas cleaning system Benzo(b and k) fluoranthenes.	Less than 0.5~~ng~~/m^3 ug	-	21

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(k) Fluoranthene	207-08-9	Gasifier using wastes such as residential garbage and agricultural wastes (Benzo (b and k) fluoranthenes.	-	-	15
		Gasoline vehicle, FTP test, cold start, benzo (b and k) fluoranthenes	6.8µg/km	-	7
		Gasoline-catalyst vehicle FTP test, cold start, Benzo (b and k) fluoranthenes	0.4µg/km	-	7
		Gasoline - 15% methanol FTP test, cold start, Benzo (b and k) fluoranthenes	3.6µg/km	-	7
		Diesel vehicle, FTP test, cold start, Benzo (b and k) fluoranthenes	37µg/km	-	7
		Oil fired central heating system, light oil (oil burner) Benzo (b and k) fluoranthenes	50ng/kg fuel	-	12
		Diesel Engine, ECE test Benzo (y and k) fluoranthenes	23ng/liter	-	12
		1978 Oldsmobile diesel engine particulates extract (Benzofluoranthenes)	identified	-	33
		Solvent extracts of emissions collected from flames fueled by hydro carbon(s) -air mixture (as % amounts)		-	31
		Toluene	0.30	-	31
		Toluene/Heptane	0.16	-	31
		Heptane	0.26	-	31
		Coke production, Steel Mill, Ontario	Identified	1977-78	30

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo (k) fluoranthene	207-08-9	Pilot plant - coal gasification base-neutral water extract of raw gas		-	128
		Snbbituminous coal (as benzo(b) fluoranthene/ benzo(k) fluoranthene)	2.0mg/1		
		Wood stove, varying burn modes - side draft, updraft, down draft, high turbulance draft. Total wood burned 6.33 to 6.79 kg (as benzofluoranthenes)		-	129
		Seasoned oak (low-high)			
		particulates	0.11-14mg		
		gaseo~~n~~us	0.86-17mg		
		Green pine (~~high~~ side draft)			
		particulates	21 mg		
		gaseons	0.15mg		
		Wood stove with a catalytic combustor, condensable fraction		-	75
		Before the combustor	40~~mg~~ ug/of organics		
		After the combustor	Below detection limit		
		Coal combustion, residential, bituminous coal, washed, unwashed, blends, as benzofluoranthenes	0.014lb/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests (as benzofluoranthenes)		-	79
		low altitude test	0.0112g/~~1g~~ kg		
		high altitude test	0.0021g/~~1g~~ kg		
		Electric power plant boiler, medium sulfur eastern coal tangentaiilly fired, equipped with electrostatic precipitator, USA (as benzofluoranthene).	0.2-1.2~~mg~~ ug 0.5-18.7~~mg~~ ug 0.2-45~~mg~~ ug	-	98

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(k) fluoranthene	207-08-9	Amount in unknown sample size, low-high ranges, 3 test results.			
		Coke oven batteries; ratios of benzofluoranthenes to perylene	2.9,3.6	—	99
		Petroleum refineries ration of concentration of benzofluoranthene to benzo(e) pyrene.	1.43	1971-72	100
		In carbon paper (μg/ sheet)	2.5	—	113
		Coal fly ash, tentative	identified	—	121
		Boiler fired by pulverised coal equipped with electrostatic precipitator. [Benzo (b and k) flouranthenes]	Less than 0.1 $\mu g/m^3$	-	21
		Boiler fired by coal; equipped with baghouse filter for cleaning flue gas. [Benzo (b and k) flouranthenes]	Less than 0.07 $\mu g/m^3$	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter. [Benzo (b and k) fluoranthenes]	25 $\mu g/m^3$	-	21

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
11H-Benzo (a) fluorene -11-one	479-79-8	1978 Oldsmobile diesel engine particulate extract as 11-benzo (a) fluonenone or benzoanthrone	identified	-	33

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Fluidized bed coal combustion	0.25,0.25 $\times 10^{-5}$ ng/J	-	28
		Wood heaters: (as Indeno(1,2,3 -cd) pyrene/Benzo(ghi) perylene)		-	53
		Heater 1 - nonbaffled airtight circulator	0.0043gm/kg wood		
		Nonbaffled airtight catalytic radiant heater	0.0003gm/kg wood		
		Retrofit add on catalytic combustor added to heater 1	0.0020gm/kg wood		
		Baffled airtight catalytic circulator with metal based catalyst	0.0013gm/kg wood		
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value	4-100ng/m^3	-	51
		Pilot plant coal gasification gas, water soluble components, lignite coal	Identified	-	128
		Pilot plant coal gasification, base-neutral water extract of raw gas		-	128
		Snbbituminous coal	0.5mg/1	-	128
		Lignite coal	0.2mg/1		
		Gasifier, using wastes such as residential garbage and agricultural wastes	-	-	15
		Coke production, Steel Mill, Ontario	detected	1977-78	30
		Pilot plant foundry - air samples, Finland	detected	-	29

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Iron foundry, airborne particulate matter, Finland	detected	-	29
		Pyrolysis of iron foundry molding sands, Finland (as % of 10 PAHS, two samples)	0.09% and 0.03%	-	29
		Wood combustion: as Zero clearance fireplace		-	26
		Green pine	0.0015gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0045gm/kg wood		
		Green pine	0.0099 gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0043gm/kg wood		
		Green pine	0.0048gm/kg wood		
		Laboratory coal gasification (blends of different coals)	0.2ng/J		
		Coal combustion (two samples)	(14.2; 104) x10^{-3}ng/J Coal energy		
		Anthracite coal briquettes, assuming BaP emissions = 100	150	-	3
		Brow Coal, assuming BaP emissions = 100	400	—	3
		Coal, assuming BaP emissions = 100	1250	—	3
		Oil stove, assuming BaP emissions = 100	500	—	3
		Automobile exhaust Condensate assuming BaP emissions = 100	1	—	3
		Power Plan Boilers:		-	21
		Boiler fired by heavy fuel oil without flue gas cleaning systems	Less than 0.5µg/m^3	-	21

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 0.1μg/m^3	- -	21 21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	Less than 0.7μg/m^3	-	21
		Boiler fired by coal, inefficient combustion, equipped with baghouse filter.	4μg/m^3	-	21
		Vehicle, in an ECE test	32μg/km	-	7
		Volkswagan Rabbit(1978) diesel fuel; FTP test	6μg/km	-	7
		Golf (1979), gasoline FTP test.	4μg/km	-	7
		3 types of vehicles, FTP test, hot start, low-high range.	5-8μg/km	-	7
		3 types of vehicles, FTP test, cold start, low-high range.	13-44μg/km	-	7
		Gasoline vehicle, FTP test, cold start.	3.9μg/km	-	7
		Gasoline - catalyst vehicle, FTP test, cold start.	0.7μg/km	-	7
		Gasoline - 15% methanol FTP test, cold start.	5.2μg/km	-	7
		Diesel vehicle, FTP test, cold start.	22 μg/km	-	7
		Hand stoked residential stove, coal briquettes combustion, flue gas.	13μg/m^3	-	12
		Oil fired central heating system, light oil, oil burner.	25ng/kg fuel	-	12
		Diesel Engine, ECE test.	38ng/liter fuel	-	12
		Engine, gasoline, ECE test.	225μg/liter fuel	-	12
		Coke oven batteries ratio of Benzo(ghi) perylene to perylene	1.4; 3.0; 3.1	-	99

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Petroleum re~~g~~fineries; ratio of concentration of benzo(ghi) perylene to benzo(e) pyrene.	2.46	1971-72	100
		Residential wood stove (μg/kg dry fuel burned)		—	126
		Birch: normal combustion	544		
		Birch: starved combustion	188		
		Spruce: normal combustion	34		
		Spruce: starved comustion	285		
		Residential charcoal stove; to be reduced by a factor of 3 to 4 for comparison with wood (μg/kg dry fuel burned)	0.1		
		Wood stove: varying burn modes - side draft, up draft, down draft, high turbulance draft. Total wood burned 6.33 to 6.79kg.		-	129
		Seasoned oak (low-high)			
		particulates	0.13-22mg		
		gaseons	0.09-3.2mg		
		Green pine (side draft)			
		particulates	30mg		
		Wood combustion, non-baffled stove burning seasoned oak, high/low altitude tests		—	79
		low altitude test	0.0043g/kg		
		high altitude test	0.001g/kg		
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA	0.3-0.5ug 0.1-0.3ug	—	98
		Amount in unknown samples size, low-high ranges, 3 test results.			

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Diesel engine, a composite of ~~few~~ten commercial No. 2 diesel fuels.	Identified	-	99

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Anthracite Coal briquettes	100 (arbitrary value)	-	3
		Anthracite Coal	100 (arbitrary value)	-	3
		Brown Coal	100 (arbitrary value)	-	3
		Coal	100 (arbitrary value)	-	3
		Oil Stove	100 (arbitrary value)	-	3
		Automobile Exhaust Condensate	100 (arbitrary value	-	3
		Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5~~mg~~ ug/m^3	-	21
		Boiler fired by pulverised coal equipped with electrostatic precipitator.	Less than 0.1~~mg~~ ug/m^3	-	21
		Boiler fired by coal, equipped with baghouse filter for cleaning flue gas.	Less than 0.07~~mg~~ ug/m^3	-	21
		Boiler fired by coal, inefficient combustion, equipped with baghouse filter.	12~~mg~~ ug/m^3	-	21
		Diesel Particulate Extract.	0.07pp~~d~~b	-	10
		Vehicle in a ECE test.	10~~mg~~ ug/km	-	7
		Volkswagon Rabbit (1978), diesel fuel, FTP test procedure.	5~~mg~~ ug/km	-	7
		Golf (1979); gasoline FTP test procedure.	6~~mg~~ ug/km	-	7
		Fiat 126, ECE test.	10~~mg~~ ug/km	-	7
		Fiat 128, ECE test.	5~~mg~~ ug/km	-	7
		Japanese; City Mode Driving cycle	2.5~~mg~~ ug/km (mean of 5 vehicles)	-	7

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Three types of vehicles FTP test, Hot Start, Low-High Ranges.	2-7~~mg~~ug/km	-	7
		Three types of vehicles, FTP test, Cold Start, Low-High Ranges.	8-25~~mg~~ug/km	-	7
		Two Diesel vehicles, FTP test.	0.5-3.9~~mg~~ug/km	-	7
		Two gasoline vehicles FTP test.	3-3.2~~mg~~ug/km	-	7
		Two gasoline-catalyst vehicles, FTP test.	0.1-<0.1~~mg~~ug/km	-	7
		Vehicle (1969) FTP test.	12~~mg~~ug/km	-	7
		Vehicle (1970) FTP test.	7.5~~mg~~ug/km	-	7
		Vehicle (1972) FTP test.	3.3~~mg~~ug/km	-	7
		Engines run on LPG	Less than 0.1~~mg~~ug/km	-	8
		Engines run on leaded gasoline.	1-10~~mg~~ug/km	-	8
		Engines run on gasoline; catalyst equipped	0.1-1~~mg~~ug/km	-	8
		Engines run on gasohol.	1-10~~mg~~ug/km	-	8
		Engines run on diesel.	1-10~~mg~~ug/km	-	8
		Engines run on 95% methanol.	Less than 0.1~~mg~~ug/km	-	8
		Engine, Gasoline, UK.	0.10-0.12gms/ ton gasoline	-	13
		Engine, Diesel, UK.	0.08-0.10g/ton diesel	-	13
		Carbon Black; Extractable Organic Matter.	0.02-0.05~~mg~~ug/mg	-	25
		Diesel Particles, Extractable Organic matter	0.002-0.09~~mg~~ug/mg	-	25
		Gasifier using wastes such as residential garbage or agricultural wastes.	unknown	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Oil fired central heating system; light oil (Oil burner).	25ng/kg oil	-	12
		Hand sto~~r~~ked residential stove (flue gas, coal briquettes).	21~~ng~~ug/m^3	-	12
		Diesel Engine; ECE test.	30ng/liter fuel	-	12
		Engine, Gasoline ECE test.	99~~ng~~ug/liter fuel	-	12
		Diesel Engine; Oldsmobile (1978) Hot start, FTP test, Commercial diesel oil.	Unknown	-	33
		Coke oven battery	172-15,900ng/m^3	-	12
		Coke oven battery surroundings.	21-6700ng/m^3	-	12
		Above coke oven gasworks retorts.	216000ng/m^3	-	12
		Municipal incinerator	17-2700ng/m^3	-	12
		Commercial Incinerator	11000-52000 ng/m^3	-	12
		Silicon Carbide plant	28-900ng/m^3	-	12
		Coal fired power plants.	30-930ng/m^3	-	12
		Coal fired furnace residential.	2200-1,500,000 ng/m^3	-	12
		Tarring operations:			
		Roof:	90,1870,14000 ng/m^3	-	12
		Sidewalk:	52,110; 78,000 ng/m^3	-	12
		Tar paper plant	38-1500ng/m^3	-	12
		Wall tarring operations (depending on ventilation and smoking).	520,000; 640,000; 1600,000 6000,000ng/m^3	-	12
		Gas works retort houses	3000ng/m^3	-	12
		Above gas works retorts	220,000ng/m^3	-	12

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Heat generation source; gas fired.	20-350ng/m^3	-	12
		Heat Generation Source, oil fired	20-1900ng/m^3	-	12
		Open burning (unspecified)	2800; 4200; 173,000ng/m^3	-	12
		Iron Foundry, Finland Dust samples, during work periods.	0.2 to 4.9~~ng~~ug/m^3	-	29
		Iron Foundry; using coaltar pitch	Avg:2.3~~ng~~ug/m^3 0.1-4.9~~ng~~ug/m^3 (mean) 0.01-57.5~~ng~~ug/m^3 (range)	-	29
		Iron Foundry coal powder	0.01 to 0.08~~ng~~ug/m^3 (mean) 0.01-0.82~~ng~~ug/m^3 (range)	-	29
		Iron Foundry molding sands pyrolysis (% amounts)	0.9-1.5	-	29
Benzo(a) pyrene and other benzopyrenes and perylene	-	Wood burning fire place, zero clearance with heat circulation; Seasoned oak	Less than 0.0014gm/kg wood	-	26
		Green Pine	0.0014gm/kg wood	-	26
		Wood stove, airtight baffled. Seasond Oak ~~Seasoned Oak~~	0.0083gm/kg wood	-	26
		Green Pine	0.0116 gm/kg wood	-	26
		Nonbaffled wood stove, airtight. Seasoned oak	0.0084 gm/kg wood	-	26
		Green Pine	0.0094 gm/kg wood	-	26
Benzo(a) pyrene	50-32-8	Laboratory Coal Gasifier using various USA ~~colas~~ coals; 90% blended with 30% limestone; and 79% blended with 21% hardwood pellets.	1.1ng/J	-	28

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Hydro carbon fuel flames; Solvent Extracts %,		—	31
		Toluene fuel	0.30%		
		Toluene/Heptane fuel	0.41%		
		Heptane fuel	0.90%		
		Coal Combustion (various USA coals)	(2.0, 720)$\times 10^{-5}$ ~~x 10-5~~ ng/Joule	-	28
		Fluidized bed Coal Combustion (various USA coals)	(0.01,0.02)$\times 10^{-5}$ ~~x 10-5~~ ng/J	-	28
		Wood stoves burning oak, maple and pine, Canada	3-80 ~~ng~~ ug/kg wood	-	55
		Wood burning furnace, oak, maple and pine, Canada	trace -2.7 ug ~~ng~~/gm Particulates	-	55
		Wood heater, air tight, non baffled.	0.0065 g/kg wood	-	53
		Wood heater, air tight, catalytic non baffled.	0.0007g/kg wood	-	53
		Wood heater, catalytic retrofit.	0.0026g/kg wood	-	53
		Wood heater, baffled airtight, catalytic with metal catalytic base.	0.0016g/kg wood	-	53
		Wood heater, airtight with secondary combustion features.	0.0008g/kg wood	-	53
		Coal fired fluidized bed power plant pilot-plant, 4 determinations with temperature variation in the 4th determination.	16,3,2 and 310 ng/m^3	-	57

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Petroleum Road Asphalt; Laboratory Simulation; two samples.	168ng/m^3 and 320ng/m^3	-	46
		Range with variations in selected parameters	Not detectable - 478.8ng/m^3		
		Atmosphere of Oil tankers during refitting		—	107
		before cutting	6mg/1000m^3		
		during cutting	3mg/1000m^3 to 8.25mg/1000m^3		
		Coal gasification pilot plant, base-neutral water extract of raw gas:		-	128
		Subbituminous coal	4.7mg/l	-	
		Lignite coal	2.0mg/l		
		Wood Combustion as % of total PAH.		-	74
		Furnace with prechamber, wood chips	Less than 7.5% Less than 0.38% Less than 0.45% 1.74%		
		Furnace, with wood	2.31%		
		Furnace, with wood	0.69%		
		Furnace, with wood	0.61%		
		Modified fireplace; with wood	2.2%		
		Modified fireplace with wood	2.4%		
		Modified fireplace; with wood	2.54%		
		Modified fireplace; with wood	2.53%		
		Airtight stove with wood	1.92% 0.53% 3.17% 3.02% 2.36%		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Wood stove, varying burn mode (side draft, up draft, down draft, high turbulence draft), seasoned oak or ~~on~~ pine green; Total wood burned: 6.33 to 6.79 kg		-	129
		Particulates; mass range	.07-13mg		
		Gaseous; mass range	0.08-6.5mg		
		In Gaseous samples, Range Downdraft, Oak Sidedraft, Pine	0.2mg/m^{3}to 10mg/m^3		
		Thermal Power Generation, Peat		-	76
		25kw	5x10^6gms per 1000w		
		300kw	1.25x10^4 gms per 1000w 990gms per 1000w		
		5x10^4kw	1000, 600, 60gms per 1000watts		
		5.6x10^4kw	10gms per 1000w		
		Thermal Power Generation, Oil			
		55kw	2.5x10^3gms per 1000w		
		8.0~~80~~x10^5kw	2.5gms per 1000w		
		8.5x10^5kw	0.9gms per 1000w		
		Coal:			
		20kw	6.25x10^6gms per 1000w		
		6x10^5kw	62.5gms per 1000w		
		4x10^5kw	0.625gms per 1000w		
		5.5x10^5kw	0.125gms per 1000w		
		Coal Combustion, residential, Bituminous coal; high ash, unwashed; includes perylene.	0.012lb per ton	-	130

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Wood combustion, high altitudes, tests. Nonbaffled stove burning seasoned oak; includes ~~pyrene~~ perylene		-	79
		Low altitude	0.0084g/kg wood	-	
		High altitude	0.0020g/kg wood		
		Wood stove, Norway operated at normal and starved conditions.		-	126
		Birch, Normal conditions	560~~ng~~ug/kg		
		Birch; Starved cond.	237~~ng~~ug/kg		
		Spruce; Normal cond.	46~~ng~~ug/kg		
		Spruce; Starved cond.	6]7~~ng~~ug/kg		
		Charcoal;	0.3~~ng~~ug/kg		
		Coal combustion fly ash as % of fly ash extract	0.115±.007%	-	121
		Cement refractory using coal tar pitch and coal tar creosote Pennsylvania, USA Personal Air samples	0.3-4.98 ug ~~ng~~/m^3	September 26-27 1979	88
		Steel company Pueblo, Colorado. Breating zone samples	0.0003 -0.002 mg/m^3	July,1980	89
		Aluminum Plant Ravenswood, West Virginia, Personal Air Samples	none detected to 3.80~~ng~~ug/m^3 Mean: 0.29~~ng~~ug/m^3	April 1979	90
		Aluminum Plant Louisiana, USA Potroom	2.64 to 3.84~~ng~~ug/m^3		91
		Range: Plant:	0.05 to 8~~ng~~ug/m^3	April 6,7 1978	
		Background:	Less than 0.05 to 0.07 to less than 0.10~~ng~~ug/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Asphalt Shingles Plant, Pittsburg, California, USA			93
		Saturator	1.8~~mg~~ug/m³	April 29,1977	
			3.44~~mg~~ug/m³	Aug 4 1977	
		Main work area Saturator	0.35~~mg~~ug/m³	April 29,1977	
		Coater, general area	0.10~~mg~~ug/m³	Aug 4 1977	
		USA Petroleum Catalytic cracking;fluid catalytic cracking	0.000022 to 0.0024 tons/year	1977	96
		Thermofor Catalytic Cracking	0.000015 to 0.035 tons/ year	1977	
		Houdriflow ~~Hydro~~ Catalytic	0.0044 to 0.0048 tons/ year	1977	
		Asphalt production	0.00035 to 0.017 tons/ year	1976	
		Air blowing	0.0014 to 0.025 tons/ year	1976	
		Hot Road Mix	0.012 to 0.013 tons/ year	1976	

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	USA			96
		Iron and Steel sintering	0.022 to 41 tons/yr		
		Forest Fires	9.5 to 127 tons/yr	1976	
		Mobile Sources, Rubber Tire Wear	0-11 tons/yr	1977	
		Residential Furnaces ($<$210,000 BTU/hr)			
		Wood	17000 ~~mg~~ μg/kg		
		Coal	3500 ~~mg~~ μg/kg		
		Oil	2.2 ~~mg~~ μg/~~kg~~ ℓ		
		Gas	2 ~~mg~~ μg/~~kg~~ m^3		
		Immediate and Industrial Boilers ($<30\times10^6$ BTU/hr)			
		Coal	0.9 ~~mg~~ μg/kg		
		Oil	1.1-32ng/1		
		Gas	0.6-7.6ng/m^3		
		Coal fired utility Boiler; USA	-		98
		Petroleum Refinery, USA relative to (Benzo(e) pyrene)	~~2.85~~ 3.85	-	100
		Ferro alloy furnaces Emission mg per ~~mg~~ Mg ~~fuel~~ feed.			108
		Si Metal, Open furnace	0.050		
		50% FeSi, Open furnace	0.005		
		50% FeSi, Covered furnace	8.92		
		McFeMn, Open furnace	0		
		McFeMn Covered furnace	0.018		
		SiMetal; Open furnace	0.018		
		50% FeSi;Open furnace	0		
		50% FeSi, Covered furnace	0.053		
		HCFeMn Open furnace	0		
		HCFeMn Covered furnace	0.00005		
		One of three Open furnace exhaust gas (avg.)	0.21 ~~mg~~ μg/m^3		
		Covered furnace	$>$0.02 ~~mg~~ μg/m^3		

EMISSIONS

	R	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	SiMetal Furnace Gas (B (a) P and B (e) P) from baghouse outlet.	55~~ng~~ug/m^3		
		Foundries, Ontario 3 steel, 3 iron; 2 non ferrons, 2 ferrons and non ferrons			109
		Personal samples (maximum)	8.15~~ng~~ug/m^3		
		Area samples (maximum)	12.06~~ng~~ug/m^3		
		Occupational, Mean Range	0.09-1.18~~ng~~ug/m^3		
		Occupational; Max Range	0.52-8.15 ug~~ng~~/m^3		
		Area samples Mean	1.78~~ng~~ug/m^3		
		Steel Foundry	0.43~~ng~~ug/m^3		
		Iron Foundry	0.94-~~ng~~ug/m^3		
		Non Ferrons foundry	0.01~~ng~~ug/m^3		
		Ferrons and nonferrons mixed metal foundry	0.63~~ng~~ug/m^3		
		Seasonal variations			
		Winter	0.64~~ng~~ug/m^3		
		Spring	0.74~~ng~~ug/m^3		
		Summer	0.06~~ng~~ug/m^3		
		Variations in ventillation			
		Poor	0.94~~ng~~ug/m^3		
		Good	0.23~~ng~~ug/m^3		
		Excellent	0.02~~ng~~ug/m^3		
		Coal Fired Boilers (gms B(a)P per ton coal burned)			
		Hard fired (<0.2 BTU/Lv)	45		111
		Hard fired (0.2 - 10 BTU/~~Lv~~hr)	4.5		
		Underfeed Stoker (0.2 BTU/~~Lv~~hr)	1.1		
		Underfeed Stoker (0.2-10 BTU/~~Lv~~hr)	0.14		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Underfeed Stoker (10-100 BTU/~~hr~~ hr)	0.003		
		Underfeed Stoker (1000 BTU/~~hr~~ hr)	0.0003		
		Spreader Stoker (10-100 BTU/~~hr~~ hr)	0.0018		
		Spreader Stoker (1000 BTU/~~hr~~ hr)	0.0014		
		Other Stoker (0.2-10 BTU/~~hr~~ hr)	0.0018		
		Other Stoker (10-100 BTU/~~hr~~ hr)	0.0018		
		Pulverized coal fired (10-100 BTU/~~hr~~ hr)	0.002		
		Pulverized coal fired (1000 BTU/~~hr~~ hr)	0.002		
		Pulverized other (1000 BTU/~~hr~~ hr)	0.002		
		Incineration (gms BaP per ton refuse burned)			111
		(10-100 BTU/~~hr~~ hr)	0.31		
		Coke Production (gms BaP per ton of Coke produced)	2.0		
		Petroleum Refining (gms BaP per barrel of crude processed).	0.00024		
		Residential Coal fired furnaces (gms per ton of coal burned)	23		
		Organic ~~seal~~ soil burning Range Average	 13-1178~~gm~~ μg/kg 319~~ng~~ μg/kg		131

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) Pyrene	50-32-8	Electric power plant medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator USA (as benzo(a) pyrene and benzo (e) pyrene. Amount in unknown sample size, low-high ranges, 3 test results.	0.8~~ng~~ ug 6.2-11.7~~ng~~ ug 0.1-5.4~~ng~~ ug	-	98
		Minimum-Maximum ranges			109
		Bus garage - area samples	0.003-0.47~~ng~~ ug/m^3		
		Gas works retort house, ~~not available~~ area samples	~~23-30ng/m^3~~ not available - 23.3 ug/m^3		
		Iron and steel works area samples	0.040-4.17 ug ~~ng~~/m^3		
		Industrial plant, area samples	0.180-7.3 ug/m^3		
		Roof tarring, area samples	0.001-78.0~~ng~~ ug/m^3		
		Coal and pitch coking plants, area samples			
		Lazy	0.020-296.23 ~~ng~~ ug/m^3	1963, 1965	
		Ostrava	0.050-33.28 ~~ng~~ ug/m^3	1966, 1967	
		Vitezhy	0.020-94.8~~ng~~ ug/m^3	1966	
		East Slovak	0.310-159.0~~ng~~ ug/m^3	1968	
		Iron foundried; area samples	Non-detectable 57.5~~Ng~~ ug/m^3		
		Aluminum Reduction Plant			
		Area samples	non detectable - 9.0~~ng~~ ug/m^3		
		Personal samples	0.8-116.3~~ng~~ ug/m^3		
		Coke plants, area samples	8-135~~ng~~ ug/m^3		
		personal samples	0.5-43.18~~ng~~ ug/m^3		
		Steel foundry, personal samples	0.020-0.3~~ng~~ ug/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Iron and steel foundries Area samples Presonal samples	 non detectable - 12.06~~mg~~ µg/m^3 non detectable 8.05~~mg~~ µg/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(e) pyrene	192-97-2	Anthracite coal Briquettes, assuming BaP emissions = 100	300	-	3
		Anthracite Coal; assuming BaP emissions = 100	1600		
		Brown Coal, assuming BaP emissions = 100	650		
		Coal, assuming BaP emissions = 100	4000		
		Oil Stove, assuming BaP emissions = 100	1350		
		Automobile Exhaust Condensate, assuming BaP emissions = 100	750		
		Vehicles Volkswagon Rabbit(1978) diesel fuel, FTP test	6~~ng~~ug/km	-	7
		Golf (1979), gasoline; FTP test	7~~ng~~ug/km	-	7
		Hand stoked residential stove, flue gas; coal briquettes combination.	27.5~~ng~~ug/m3	-	12
		Diesel engine, ECE test	38ng/liter fuel	-	12
		Engine, gasoline, ECE test	70~~ng~~ug/liter fuel	-	12
		Oil fired central heating system. light oil; oil burner	62.5ng/kg fuel	-	12
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		1978 Oldsmobile diesel engine particulates extract (as benzopyrenes)	identified	-	33
		Solvent extracts of emissions from flames fueled by hydrocarbon(s) -air mixture (as % amounts)		-	31

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(e) Pyrene	192-97-2	Toluene	0.16	-	31
		Toluene/Heptane	0.12	-	31
		Heptane	0.19	-	31
		Pilot plant foundry; air samples, Finland	detected	-	29
		Iron foundries, Finland airborne particulate matter	detected	-	29
		Pyrolysis of iron foundry molding sands; Finland (as % of 10 PAHs; two samples)	1.5% and 1.2%	-	29
		Wood combustion; as benzopyrenes/perylene)		-	26
		Zero clearance fire place			
		Seasoned oak	< 0.0014gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0083gm/kg wood		
		Green pine	0.0116gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0084gm/kg wood		
		Green pine	0.0094gm/kg wood		
		Wood stoves burning wood including oak, maple and pine; Canada	3-41ug/kg fuel	-	55
		Wood burning furnace emissions; Canada	trace - 1.4ug/gm particulates	-	55
		Power plant, laboratory coal fired, fluidized bed; range; temperature variation at the high value.	4-310ng/m^3	-	51
		Pilot plant coal gasification; base-neutral water extract of raw gas,		-	128

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(e) Pyrene	192-97-2	Subbituminous Coal lignite coal	4.9mg/l 1.0mg/l		
		Wood combustion: as % of total PAHs		-	74
		Furnace with pre-chamber wood chips	<7.5%		
		Fire place, wood chips	0.38% 0.45%, 1.35%		
		Furnace, wood	1.19%, 0.35% 0.28%		
		Modified fireplace wood	1.22%, 1.35% 2.54%, 2.53%		
		Airtight stove, wood	1.54%, 0.18% 1.83%, 1.59% and 1.43%		
		Wood stove, varying burn modes - side draft, up draft, down draft, high turbulence draft - total wood burned 6.33 to 6.79 kg		-	129
		Seasoned oak (Low-high)			
		particulates	0.07-3.5mg		
		gaseous	.24-3.8mg		
		Green Pine (side draft)			
		particulates	7.1mg		
		gaseous	0.08mg		
		Coal combustion, residential bituminous coal, Subbituminous coal, washed, unwashed blends		-	130
		As benzopyrene(s) and perylene	0.012 lb/ton		
		Wood combustion, nonbaffled stove burning seasoned oak; high/low altitude tests as benzo pyrenes/perylene		-	79
		low altitude test	0.0084g/kg		
		high altitude test	0.0020g/kg		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(e) pyrene	192-97-2	Gas fired utility boilers Ambient severity factor (ASF) defined as maximum ground level concentration calculated to the level at which a potential environmental hazard exists. Values as benzopyrenes and perylenes.			95
		Residual oil, tangential ~~filtering~~ firing, emission factor	6.25x10^{-7} ng/J		
		ASF	0.014		
		Resid~~ential~~ual oil, wall firing Emission factor	6.25x10^{-7} ng/J		
		ASF	0.005		
		Natural gas, tangential firing and wall firing Emission factor	Below detection Limit		
		ASF	Not applicable		
		Coal fired, pulverized wet bottom, as benzo(a) pyrene and benzo(e) pyrene Emission factor	0.0035ng/J		
		ASF	21		
		Electric power plant boiler; medium sulfur eastern coal tangentially fired; equipped with electrostatic precipitator; USA (as benzo(a) pyrene and benzo(e) pyrene) Amount in unknown sample size, low-high values ranges, 3 tests results	0.8~~ng~~ ug 6.2-11.7~~ng~~ ug 0.1-5~~ng~~ ug	-	98

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benzo(e) Pyrene	192-97-2	Diesel engine; a composite of ten commercial no. 2 diesel fuels.	identified	-	99
		Hot water boiler - combustion of wood and peat; relative to benzo(ghi)perylene		-	99
		wood	2.7		
		peat	2.4		
		Coke oven batteries ratio of B(e)P to perylene.	2.9,2.2	—	99
		Residential Wood stove (~~ng~~ μg/kg dry fuel burned)			126
		Birch: normal conditions	350		
		Birch: starved conditions	166		
		Spruce: normal conditions	35		
		Spruce: starved conditions	347		
		Residential Charcoal stove: (ng/kg/dry fuel burned) to be reduced by a factor of 3-4 for comparison with wood.	0.5		
		In carbon paper(~~ng~~ μg/ sheet)	15.2		113
		Coal fly ash, tentative as benzo pyrenes	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Biphenyl	92-52-4	Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		Extract of soot collected from flames; benzene - air mixture fuel, % extract fraction range in 40°c to 200°c.	89-0.46	-	31
		Solvent extract of emissions collected from flames fueld by hydro carbon(s) -air mixture (a % amounts)		-	31
		Tolueme	2.1	-	31
		Toluene/Heptane	1.4	-	31
		Heptane	0.44	-	31
		Petroleum road asphalts, simulated atmospheric and lighting conditions	Identified	-	46
		Airtight woodburning stove; seasoned oak; two sizes, two burn rates, polar fraction, condensable portion of st~~o~~ack gases.	0.3504 and 0.6301 mg/kg wood	-	73
		Wood stove with a catalytic combustor, condensable fraction.			
		Before the combustor	11~~mg~~ug/of organics		
		After the combustor	6~~mg~~ug/of organics		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends	0.018lb/ton	-	130

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Biphenyl	92-52-4	Wood combustion, nonbaffled stove burning seasoned oak, low/high altitude tests.			
		low altitude	-		
		high altitude	0.0016g/kg		
		Lignite fired utility boilers, cyclone equipped		-	95
		emission factor	0.0002ng/Joule		
		Ambient severity factor (ratio of maximum ground level concentration calculated to the level at which a potential hazard exists)	$<$ 0.0001		
		Ferroalloy furnaces Open silicon metal	141ug/m^3		
		gas phase emissions	92.4gms/hr		
		Covered ferrosilicon furnace, secondary fume; gas phase	37ug/m^3		
		emissions	24gms/hr		
		In carbon paper (ug/sheet)	1.6		113
		Coal fly ash (tentative)	identified		121
		Polycaprolactam nylon operations	identified	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Carbazole	86-74-8	Coal Liquefaction pilot plant, USA	-	-	15
		Pilot plant coal gasification gas, water soluble components - subbituminous coal and peat	Identified	-	128
		Pilot plant coal gasificati-n, base-neutral water extract of raw gas.		-	128
		Subbituminous coal	2.9mg/1		
		Lignite coal	0.5mg/1		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Wood combustion (as benzo(a) anthracene/ chrysene)		-	26
		Zero clearance fire place.			
		Seasoned oak	< 0.0014gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0125gm/kg wood		
		Green pine	0.0138gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0076gm/kg wood		
		Green pine	0.0371gm/kg wood		
		Laboratory coal gasification (blends of different coals) as benzo(a)anthracene and chrysene)	23ng/J	-	28
		Coal combustion(two samples)	(1.7;1.7)x10-5 ng/Joule coal energy	-	28
		Fluidized bed coal combustion (two samples)	(0.1; 13)x10-5 ng/J	-	28
		Wood stoves burning wood including oak, maple and pine; Canada as chrysene and triphenylene.	2-139~~ng~~ug/kg fuel	-	55
		Woodburning furnace emissions, Canada as Chrysene and tripheny line.	trace - 4.7~~ng~~ug/gm particulates	-	55

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Wood heaters (as chrysene/benzo(a) anthracene)		–	53
		Heater 1 - nonbaffled airtight circulator.	0.0102 gm/kg wood		
		Baffled airtight catalytic radiant wood.	0.0013 gm/kg wood		
		Retrofit add on catalytic comubstor added to heater 1.	0.0075gm/ kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0049 gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0018 gm/kg wood		
		Power plant; laboratory coal fired fluidized bed, range, temperature variation at the high value.	$<$60-7600ng/m^3	-	51
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46
		Pilot plant coal gasification gas, water soluble components, peat.	Identified	-	128
		Pilot plant coal gasification base - neutral water extract of raw gas (Chrysene/triphenylene)		-	128
		Subbituminous coal	3.6mg/1		
		Ligmite coal	1.4mg/1		
		Airtight wood stove seasoned oak, two sizes, two burn rates, as benzo(a)anthracene/chrysene.	0.44 and 1.35mg/ kg wood	-	73
		Baffled stove, seasoned oak, as benzo(a) anthracene/chrysene.	12.5mg/ kg wood	-	73

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Airtight wood burning stove, seasoned oak two sizes, two burn rates, polar fraction condensable fraction of stack gases.	0.2929 and 0.8729 mg/kg wood	-	73
		Wood stove: varying burn modes - side draft, up draft, down draft, high turbulence draft. Total wood burned 6.23 to 6.79 kg			
		Seasoned oak (low-high)			
		particulates	0.11-5.6mg		
		gaseons	1.1-8.5mg		
		Green pine (side draft)			
		particulates	3.2mg		
		gaseo~~n~~us	0.21 mg		
		Wood stove with a catalytic combustor, condensable fraction:		-	75
		Before the combustor	60 ~~mg~~ ug/of organics		
		After the combustor:	14 ~~mg~~ ug/of organics		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, blends, unwashed.		-	130
		as ~~in~~ chrysene/benzo(a) anthracene.	0.014 lb/ton		
		Refractory cements plant, USA	0.31 to 3.26 ~~ng~~ ug/m^3	6/27/79 9/26-27/79	88
		Personal air samples low-high range	0.31 to 3.26 ug ~~ng~~/m^3	9/26-27/79	
		Aluminum plant, Ravenswood, West Virginia. USA	Not detected to 4.90 ~~ng~~ ug/m^3	1979	90
		mean	0.43 ~~ng~~ ug/m^3		
		Aluminum plant, Chalmette, Louisans, USA		~~-~~	91
		Range, pot room	3.8-6.4 ug ~~ng~~/m^3		
		Range	0.16-11.6 ug ~~ng~~/m^3	4/6-7/78	
		Background	<0.21 and <0.28ng/m^3	4/6-7/78	

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator USA (as chrysene/ benzo(a)anthracene). Amount in unknown sample size, low-high ranges 3 test results.	0.1-3.2~~ng~~µg 0.2-45.4~~ng~~µg 0.4-119.7~~ng~~µg	-	98
		Power plant boilers Boiler fired by heavy fuel oil without flue gas cleaning systems.	Less than 0.5~~ng~~µg/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 0.1~~ng~~µg/m^3	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	Less than 0.07~~ng~~µg/m^3	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter.	10~~ng~~µg/m^3	-	21
		Diesel Particulate Extract	0.18ppb	-	10
		Vehicles in an ECE test.	48~~ng~~µg/km	-	7
		Gasoline vehicle, FTP test, cold start.	6.9~~ng~~µg/km	-	7
		Gasoline catalyst vehicle, FTP test, cold start.	0.2~~ng~~µg/km	-	7
		Gasoline - 15% methanol FTP test, cold start	2.5~~ng~~µg/km	-	7
		Diesel vehicle, FTP test, cold start	46~~ng~~µg/km	-	7
		Coal liquefaction pilot plant.	-	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Ha~~r~~nd stoked residential stove, coal briquettes, flue gas.	45~~ng~~ug/m^3	-	15
		Oil fired central heating system, light oil, oil burner.	250ng/ kg fuel	-	12
		Diesel Engine, ECE test	70ng/liter fuel	-	12
		Engine, gasoline, ECE test	103~~ng~~ug/liter fuel	-	12
		Gasifier using wastes such as residential garbage and agricultural wastes, (chrysene/ triphenylene)	-	-	15
		1978 Oldsmobile diesel engine particulates extract.	Identified	-	33
		Solvent extract of emissions from flames fueled by hydrocarbon(s) air mixture (as % amounts)	-	-	31
		Toluene	0.6	-	31
		Toluene/Heptane	0.16	-	31
		Heptane	0.19	-	31
		Pyrolysis of iron foundry molding sands, Finland (as % of 10 PAHs, two samples, chrysene or a compound with Molecular weight = 228).	15% and 12%	-	29
		Diesel engine, a composite of ten commercial No. 2 diesel fuels.	Identified	-	99
		Ferroyalloy furnaces.		—	108
		Open silicon metal Gas phase	10~~ng~~ug/m^3		
		Emissions	7gms/hr		
		Covered ferrosilicon furnaces, secondary fume gas phase (approximate)	2~~ng~~ug/m^3		
		emissions (approximate)	1gms/hr		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Foundries Ontario (as benzo(a)anthracene and chrysene)			109
		Personal samples max	9.39~~ng~~ug/m^3		
		Area samples, max	22.10~~ng~~ug/m^3		
		Personal samples, mean range	0.46-1.80 ug ~~ng~~/m^3		
		Personal samples, max range	0.59-9.39 ug ~~ng~~/m^3		
		Area samples, mean	2.90~~ng~~ug/m^3		
		Varying factor:			
		ventilation: Poor	2.06~~ng~~ug/m^3		
		Good	0.32~~ng~~ug/m^3		
		Very good	0.87~~ng~~ug/m^3		
		Season: summer	0.14~~ng~~ug/m^3		
		spring	0.77~~ng~~ug/m^3		
		winter	2.01~~ng~~ug/m^3		
		Type: steel	0.81~~ng~~ug/m^3		
		Iron	2.48~~ng~~ug/m^3		
		Non ferrons	0.07~~ng~~ug/m^3		
		Ferrons-non ferrons	0.81~~ng~~ug/m^3		
		Residential wood stove (~~ng~~ug/kg dry fuel burned)			126
		Birch: normal combustion	615		
		Birch: starved combustion	481		
		Spruce: normal combustion	not available		
		Spruce: starved combustion	829		
		Residential charcoal stove (~~ng~~ug/kg dry fuel burned) to be reduced by a factor of 3 to 4 for comparison with wood. Data as chrysene and triphenylene for both types of stoves.			
		In carbon paper (~~ng~~ug/sheet) as chrysene and triphenylene	11.0		113
		Coal fly ash, tentative	Identified		121
		Carbon black ~~boot~~ Soot	Identified	-	137
		Premixed acetylene oxygen flames.	Identified	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Coronene	82-02-0	Brown coal, assuming BaP emissions = 100	125		3
		Oil stove, assuming BaP emissions = 100	600		3
		Automobile exhaust Condensate, assuming BaP emissions = 100	200		3
		Vehicle in an ECE test.	20~~ng~~ug/km	-	7
		Volkswagon Rabbit (1978) ~~as~~ in a FTP test, diesel fuel.	1~~ng~~/km ug	-	7
		Golf (1979) gasoline FTP test.	1~~ng~~ug/km	-	7
		Fiat 128, ECE test.	4~~ng~~ug/km	-	7
		3 types of vehicles, FTP test, hot start, high-low ranges.	2-4~~ng~~/km ug	-	7
		3 types of vehicles FTP test, cold start, high-low ranges.	6-21~~ng~~ug/km	-	7
		Gasoline vehicle, FTP test, cold start	1.7~~ng~~ug/km	-	7
		Gasoline - catalyst vehicle, FTP test, cold start.	0.8~~ng~~ug/km	-	7
		Gasoline - 15% methanol FTP test, cold start.	4.4~~ng~~ug/km	-	7
		Diesel vehicle, FTP test, cold start.	12~~ng~~ug/km	-	7
		Aluminum plant	-	-	15
		Residential ha~~r~~nd stoked stove, coal briquettes combustion (flue gas)	1~~ng~~ug/m3	-	12
		Oil fired central heating system, light oil, oil burner.	12.5ng/kg fuel	-	12
		Diesel engine, ECE test	10ng/liter fuel	-	12
		Engine, gasoline, ECE test.	123~~ng~~ug/liter fuel	-	12
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Coronene	82-02-0	Solvent extracts of emissions from flames fueld by hydrocarbon(s)-air mixture (as % amounts)		-	31
		Toluene	0.03	-	31
		Toluene/Heptane	0.32	-	31
		Heptane	1.15	-	31
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value.	<1-<16 ng/m^3	-	51
		Wood stove: varying burn modes, side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to to 6.79 kg.		-	129
		Seasoned oak (low-high)			
		particulates	0.086-10mg		
		gaseons	0.11-0.63mg		
		Green pine (side draft)			
		gaseo~~n~~us	0.51mg		
		Diesel engine, a composite of ten commercial No. 2 diesel fuels.	Identified	-	99
		Coke oven batteries ratio of c~~a~~oronene to perylene	1.5,0.6	-	99
		Petroleum refineries ratio of concentration of coronene to benzo(e) pyrene	0.23	1971-72	100

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Cyclopenteno (c,d) pyrene	27208-37-3	Diesel Particulate extract.	0.03ppb	-	10
		Vehicles:			
		3 types of vehicles, FTP test, hot start low-high range.	0.5-11µg/km	-	7
		3 types of vehicles FTP test, cold start low-high range.	2.51µg/km	-	7
		Gasoline vahicle, FTP test, cold start.	4.5µg/km	-	7
		Gasoline - 15% methanol FTP test, cold start.	3.2µg/km	-	7
		Diesel vehicle, FTP test, cold start.	3.4µg/km	-	7
		Gasoline -catalyst vehicle, FTP test cold start.	0.06µg/km	-	7
		Engine, gasoline, ECE test.	400µg/liter fuel	-	12
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)			
		Toluene	1.2	-	31
		Toluene/Heptane	1.57	-	31
		Heptane	5.85	-	31
		Wood combustion		-	26
		Zero Clearance Fire Place			
		Seasoned oak	<0.0014gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0048gm/kg wood		
		Green pine	0.0028gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0051gm/kg wood		
		Green pine	0.0138gm/kg wood		
		Baffled stove			
		Seasoned oak	4.8mg/kg wood	-	73

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Cyclopenteno (c,d) pyrene	27208-37-3	Wood combustion, non-baffled stove burning seasoned oak, high/low altitude tests		-	79
		low altitude	0.0051g/kg		
		Residential wood stove (~~ng~~ ug/kg dry fuel burned)		-	126
		Birch: normal combustion	381		
		Birch: starved combustion	169		
		Spruce: normal combustion	40		
		Spruce: starved combustion	720		
		In carbon paper (~~ng~~ ug/sheet)	26.8	-	113
		Carbon black	Identified	-	123

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenz (a,h) acridine	226-36-8	Motor exhaust gas, benzene soluble fraction	300~~ng~~µg/kg	-	137
		Tobacco smoke, cigarettes	traces	-	137
		Domestic coal combustion stock effluent	17mg/ 1000m^3 of gas	-	137
		Petroleum refinery incinerator effluents	Less than 0.12 and 0.7mg/ 1000m^3 of gas	-	137
		Air pollution by coal tar pitch	0.01γmg/ 1000m^3 in air	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenz (a,y) acridine	224-42-0	Tobacco smoke particulates, 100 cigarettes	1.0~~mg~~ µg	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenz(a,h) Anthracene	53-70-3	Anthracite coal briquettes assuming BaP emissions = 100	35	—	3
		Anthracite coal, assuming BaP emissions = 100	110	—	3
		Brown coal, assuming BaP emissions = 100	220	—	3
		Power Plant Boilers:	-		21
		Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5µg/m^3	-	21
		Boiler fired by Pulverised coal equipped with electrostatic Precipitator.	Less than 0.1µg/m^3	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	Less than 0.07µg/m^3	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter.	1µg/m^3	-	21
		Pilot plant foundry air and iron foundry airborne particulate matter.	detected	-	29
		Finland, as dibenzanthracenes.			
		Wood combustion (as Dibenzanthracene/ phenanthrenes)		-	26
		Zero clearance fireplace			
		Green pine	0.0001gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0007gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0010gm/kg wood		
		Green pine	0.00005gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenz(a,h) anthracene	53-70-3	Woodheaters:		-	53
		Heater 1 - nonbaffled airtight circulation	0.0011gm/kg wood		
		Retrofit add on catalytic combustor added to heater 1	0.0002gm/kg wood		
		Pilot plant coal gasification, base-neutral water extract of raw gas, subbituminous coal	0.2~~ng~~mg/1	-	128
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends.	0.012 lb/ton	-	130
		Wood combustion, non-baffled, stove burning seasoned oak, low/high altitude tests as dibenzanthracenes/ phenanthrenes.		-	79
		low altitude test	0.0010g/kg		
		high altitude test	0.0003g/kg		
		Foundries, Ontario		-	109
		Personal samples, max.	12.54~~ng~~ug/m^3		
		Personal samples, mean range	0.09-1.92~~ng~~ug/m^3		
		Persomal samples, maximum range	0.61-12.54~~ng~~ug/m^3		
		Area samples, maximum	9.48~~ng~~ug/m^3		
		Area samples, mean	1.29~~ng~~ug/m^3		
		Varying factors:			
		Ventillation:			
		poor	0.69~~ng/m~~^{3} ug/m^3		
		good	0.57~~ng/m~~^{3} "		
		very good	0.04~~ng/m~~^{3} "		
		Season:			
		summer	0.21~~ng~~ug/m^3		
		spring	0.18~~ng~~ug/m^3		
		winter	1.03~~ng~~ug/m^3		
		Type:			
		steel	0.39~~ng~~ug/m^3		
		iron	0.61~~ng~~ug/m^3		
		non-ferrons	0.04~~ng~~ug/m^3		
		ferrons and non ferrons	1.35~~ng~~ug/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenz(a,h) anthracene	53-70-3	In carbon paper (~~mg~~ ug/ sheet) as dibenz ((a,c) and/or (a,h)) anthracene	6.9		113
		Soot	64-705 mg/ 1000m^3	-	137
		Gasoline engine exhaust		-	137
		First run	2.5mg/kg		
		After 1 minute	0.16 mg/kg		
		Smoke condensate 100 cigarettes	0.05-0.4~~mg~~ ug	-	137
		Cigarette smoke condensate	0.1-0.15 mg/kg	-	137

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenzo (a,h) pyrene	189-64-0	Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends. As dibenzopyrenes	 0.034 lb/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests, as dibonzopyrenes low altitude test	 0.0007g/kg	-	79
		Coal fired utility boilers ASF: ambient severity factor defined as ratio of maximum ground level concentration calculated to the level at which a potential environmental hazard exists. Boiler with pulverized dry bottom. Emission factor ASF	 0.00022ng/J 0.5	-	95
		Electric power plant boiler, medium sulfur eastern coal tangentially fired; equipped with electrostatic precipitator; USA (as dibenz(ai and ah) pyrene. Amount in unknown sample size, low high.	1.9~~ng~~ ug	-	98
		Aluminum plant (Dibenzo pyrene)	-	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenzo (a,h) Pyrene	189-64-0	Wood combustion (as dibenzopyrenes)		-	26
		Zero clearance fireplace			
		Green pine	0.0001gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0011gm/kg wood		
		Green pine	0.0010gm/kg wood		
		Air tight nonbaffled stove			
		Seasoned oak	0.0007gm/kg wood		
		Green pine	0.00002gm/kg wood		
		Laboratory coal gasification (blends of different coals)	0.5ng/J coal energy)	-	28
		Coal combustion	$<0.007 \times 10^{-5}$ ng/J	-	28
		Fluidized bed coal combustion (two samples)	(0.04;0.04) $\times 10^{-5}$ng/J	-	28 ~~29~~
		Wood stove, varying burn modes, side draft, up draft, down draft, Total woodburned 6.33 to 6.79kg.		-	129
		Seasoned oak (low-high)			
		particulates	0.12-4.2mg		
		gaseons	0.23mg		
		Green pine (side draft)			
		particulates	9.3mg		
		Air pollutants engine exhausts	may be present	-	137
		Cigarette tar, neutral fraction	Small amounts.		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Dibenzo (a,i) pyrene	189-55-9	Aluminum plant (Dibenzo pyrene)	-	-	15
		Wood combustion: (as dibenzopyrenes)		-	26
		Zero clearance fireplace			
		Green pine	0.0001gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0011gm/kg wood		
		Green pine	0.0010gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0007gm/kg wood		
		Green pine	0.00002gm/kg wood		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends		-	130
		as dibenzopyrenes	0.034 lb/ ton		
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests, as dibenzopyrenes			
		low altitude test	0.0007g/kg		
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA as dibenz (ai and ah) pyrene. Amount in unknown sample size.	- 1.9~~ng~~ µg	-	98
		Automobile exhaust	traces	-	137
		Cigarette smoke, 100 cigarettes	0.002~~0~~–1 µg ~~ng~~		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1,3-Dinitro pyrene	75321-20-9	Diesel Particulate Extract (Nitropyrenes)	1.5ppb	-	10
		1981 diesel passenger extracts.	Identified	-	65
		Coal fly ash, tentative as dinitropyrenes	Identifed		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1,6 Dinitro pyrene	42397-64-8	Diesel Particulate Extract (Nitropyrenes)	1.5ppb	-	10
		1981 diesel passenger car exhausts	Identified	-	65
		Coal fly ash, tentative as dinitropyrenes	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1,8-Dinitropyrene	42397-65-9	Diesel Particulate Extract (Nitropyrenes)	1.5ppb	-	10
		1981 diesel passenger car exhausts	Identified	-	65
		Coal fly ash, tentative as dinitropyrenes	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1-Ethyl naphthalene	1127-76-0	Solvent extract of emissions collected from flames fueled by hydrocarbon(s)-air mixture (as % amounts ethylnaphthalene)		-	31
		Toluene	0.34	-	31
		Toluene/Heptane	0.39	-	31
		Heptane	0.07	-	31
		Petroleum road asphalts simulated atmospheric and lighting conditions as ethylnaphthalene.	Identified	-	46
		Pilot plant coal gasification gas, water soluble components subbituminous coal (as ethylnaphthalene).	Identified	-	128
		Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction condensable portion of stack gases, low-high of 7 samples sets, as C_2 naphthlene.	0.0216 - 0.2861 and 0.0388-0.3909 mg/kg wood	-	73
		Wood stove with a catalytic combustor, condensable fraction as C_2 naphthalene.		-	75
		Before the combustor	42~~mg~~ ug/of ogranics		
		After the combustor	4~~mg~~ ug/of organics		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
2-Ethyl naphthalene	939-27-5	Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts - ethylnaphthalene)		-	31
		Toluene	0.34	-	31
		Toluene/Heptane	0.39	-	31
		Heptane	0.07	-	31
		Petroleum road asphalts simulated atmospheric and lighting conditions, as ethylnaphthalene.	Identified	-	46
		Pilot plant coal gasification gas, water soluble components, subbituminous coal, as ethylnaphthalene.	Identified	-	128
		Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction, condensable portion of stack gases, 7 samples sets, low-high ranges as C_2 naphthalene.	0.0216- 0.2861 and 0.0388 - 0.3909 mg~~ng~~/kg wood	-	73
		Wood stove with a catalytic combustor, condensable fraction; as C_2 naphthalene		-	75
		Before the combustor	42~~ng~~ug/of organics		
		After the combustor	4~~ng~~ug/of ogranics		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Wood combustion		-	26
		Zero clearance fire place			
		Seasoned oak	< 0.0014gm/kg wood		
		Green pine	0.0016gm/kg Wood		
		Airtight baffled stove			
		Seasoned ~~pine~~ oak	0.0180gm/kg wood		
		Green pine	0.0316gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0208gm/kg wood		
		Green pine	0.0188gm/kg wood		
		Woodstoves burning wood including oak, maple and pine, Canada.	24-471 μg ~~ng~~/kg fuel	-	55
		Wood burning furnace emissions	6-54 μg ~~ng~~/gm particulates	-	55
		Wood heaters		-	53
		Heater 1 - nonbaffled airtight circulator.	0.0067 gm/kg wood		
		Nonbaffled airtight catalytic radiant heater.	0.0017 gm/kg wood		
		Retrofit, add-on catalytic combustor added to heater 1.	0.0061 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0050 gm/kg wood		
		Air tight heated with secondary combustion provisions.	0.0024 gm/kg wood		
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value	104-78,800 ng/m^3	-	51

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Petroleum road asphalts simulated atmospheric and lighting conditions.	223ng/m^3	-	46
		Pilot plant coal gasification gas, water soluble components, subbituminous coal and lignite coal (or pyrene)	Identified	-	128
		Pilot plant coal gasification base-neutral water extract of raw gas.		-	128
		subbituminous coal	13.3mg/l		
		Lignite coal	6.2mg/l		
		1978-1980 diesel cars exhaust particulates	45.2-203ng/mg particulates		71
		Airtight woodburning stove, seasoned oak, two sizes, two burn rates	0.25 and 0.10mg/kg wood	-	73
		Baffled stove, seasoned oak	18.0mg/kg wood	-	73
		Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction	0.2146 and 0.1004mg/kg wood	-	73
		condensable portion of stack gases in creosote	0.0354mg/kg wood		
		Pulverized coal fired laboratory boiler equipped with fabric filter baghouse (6 tests) low-high range.	7-76 ug ~~mg~~/m^3	-	98
		As methylpyrene/ fluoranthene low-high range (3 tests)	~1 to 4 ug ~~mg~~/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Low sulfur coal wall fired boiler, equipped with baghouse filter baghouse inlet baghouse outlet	 0.25,0.45, 0.55~~ng~~ µg/m^3 0.25,0.45, 1.8~~ng~~ µg/m^3	-	98
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA Amount in unknown sample size; low-high ranges; 3 test results 4 tests	0.3-517~~ng~~ µg 0.3-208.4~~ng~~ µg 0.6-1137.9~~ng~~ µg 0.25-0.8~~ng~~ µg/m^3	-	98
		Diesel engine; a composite of ten commercial No. 2 diesel fuels.	Identified	-	99
		Open burning, refuse burning	Identified	-	99
		In carbon paper (~~ng~~ µg/ sheet)	40.1		113
		Incinerator - municipal and other	Identified	—	99
		Hot water boiler, combustion of wood and peat, relative to benzo (ghi) perylene wood peat	 23.5 19.4	-	9
		Ferroalloy furnaces Open silicon metal furnace, gas phase. Emissons in gms/hour. Covered ferrosilicon furnace, secondary fume; gas phase, Emissions in gms/hour	66 µg ~~ng~~/m^3 ~~49~~ 43 gms/hr 20 µg ~~ng~~/m^3 (approx) 10 gms/hr (approximate)		108
		Foundries, Ontario Personal samples, maximum level(µg/m^3) Area samples, maximum level(µg/m^3)	 3.15~~ng/m^3~~ 26.59~~ng/m^3~~		109

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Residential wood stove (~~ng~~ug/kg dry fuel burned)			126
		Birch: nromal combustion	2843		
		Birch: starved combustion	1334		
		Spruce: Normal combustion	296		
		Spruce: Starved combustion	3245		
		Residential Charcoal stove (~~ng~~ug/kg dry fuel burned) to be reduced by a fraction of 3 to 4 (in comparison with wood)	16.0		
		~~Boiler~~ Power plant boilers			
		Bolier fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5~~ng~~ug/m^3	-	21
		Boiler ~~fuels~~ fired by pulverized coal equipped with electrostatic precipitator.	0.1~~ng~~ug/m^3	-	21
		Boiler fired by coal, equipped with baghouse filter for cleaning flue gas.	0.07~~ng~~ug/m^3	-	
		Boiler fired by coal inefficient combustion equipped with baghouse filter.	200~~ng~~ug/m^3	-	21
		Diesel Particulate Extract	2.5ppb	-	10
		Gasoline Vehicle; FTP test, cold start.	12.0~~ng~~ug/km	-	7
		Gasoline-catalyst vehicle FTP test, cold start.	0.07~~ng~~ug/km	-	7
		Gasoline - 15% methanol FTP test, cold start.	3.3~~ng~~ug/km	-	7
		Diesel vehicle, FTP test, cold start.	210~~ng~~ug/km	-	7
		Ferroalloy plants	-	-	15
		Coal liquefaction pilot plant, USA	-	-	15
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	1978 Oldsmobile diesel engine particulates extract.	Identified	-	33
		Extract of soot collected from flames, benzene - air mixture fuel, % extract fraction range in 40°C and 200°C.	99-38	-	31
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)			31
		Toluene	2.3	-	31
		Toluene/Heptane	1.62	-	31
		Heptane	4.10	-	31
		Coke production, steel Mill, Ontario	Identified	1977-78	30
		Pilot plant foundry air samples, Finland	Detected	-	29
		Iron foundries; airborne particulate matter, Finland	Detected	-	29
		Pyrolysis of molding sands used in iron foundry Finland; (as % of 10 PAHs, two samples)	12% and 9%	-	29
		Wood combination as % of total PAH			
		Furnace with pre-chamber, wood chips.	< 7.5% and 11.89%	-	
		Fire place stoves, wood chips	11.03% and 12.9%	-	
		Furnace, wood	11.88%, 10.77% and 7.78%		
		Modified fireplace, wood	12.2%, 12.5%, 11.02%, 13.13%		
		Airtight stove, wood	13.46%, 13.73%, 10.0%, 11.9%, 13.57%		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Wood stove, varying burn modes - side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to 6.79kg.		-	129
		Seasoned Oak (low-high)			
		particulates	0.12-2.6mg		
		gaseous	9.1-68mg		
		Green pine (side draft)			
		particulates	2.9mg		
		gaseons	11mg		
		Wood stove with a catalytic combustor, condensable fraction		-	75
		Before the combustor	74~~ng~~ug/of organics		
		After the combustor	41~~ng~~ug/of organics		
		Coal combustion, residential bituminous coal and subbituminous coal, washed, unwashed, blends.	0.012 lb/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests.		-	79
		low altitude test	0.0208 ~~0.028~~g/kg		
		high altitude test	0.0044g/Kg		
		Refractory cements plant; USA	0.11 - 1~~ng~~ug/m^3	6/27/79 9/26-27/79	88
		Personal air samples low-high range	0.10 - 1.00 ug/m^3	9/26-27/79	
		Aluminum plant, Ravenswood, West Virginia USA, Range:	0.07 - 48 ug ~~ng~~/m^3	1979	90
		Mean	3~~ng~~ug/m^3		
		Aluminum plant, Chalmelte, USA Range	<0.05 -13.83 ug ~~ng~~/m^3	4/6-7/78	91
		Background	<0.07, 0.21 ug ~~ng~~/m^3	4/6-7/78	91

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluorantene	206-44-0	Coal fly ash, tentative	Identified		121
		Coal fly ash extract as % of extract	1.18 + .07 %		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluorene	86-73-7	Power Plant Boilers. Boiler fired by heavy oil without flue gas cleaning system	Less than 0.5ug/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 1ug/m^3	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	Less than 5ug/m^3	-	21
		Boiler fired by coal, inefficient combustion equipped with baghouse filter.	200ug/m^3	-	21
		Coal lique faction pilot plant, USA	-	-	15
		Gasifier, using wastes such as residential garbage or agricultural wastes.	-	-	15
		1978 Oldsmobile diesel engine particulates extract (as substitued C_2, C_3, C_4 fluorenes)	Identified	-	33
		Extract of soot collected from flames benzene - air mixture; % extract fraction range in 40°c to 200°c.	98 - 2.1	-	31

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluorene	86-73-7	Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)		-	31
		Toluene	7	-	31
		Toluene/Heptane	2.8	-	31
		Heptane	2.28	-	31
		Laboratory coal gasification (blends of different coals)	3.9ng/J	-	28
		Coal combustions	$45x10^{-5}$ ng/Joule coal energy	-	28
		Woodheaters:			
		Heater 1 - nonbaffled airtight circulator.	0.0075gm/kg wood		
		Nonbaffled airtight catalytic radiant unit.	0.0021 gm.kg wood		
		Retrofit, add on catalytic combustor added to heater 1.	0.0048gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0037gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0013gm/kg wood		
		Power plant, laboratory coal fired fluidized bed; range, temperature variation at the high value.	74-191000 ng/m^3	-	51
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluorene	86-73-9	Wood stove; varying burn modes; side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to 6.79 kg.			129
		Seasoned oak (low-high)			
		Particulates	0.07-0.46~~ng~~ mg		
		Gaseo~~n~~us	2.4-19mg		
		Green pine (side draft)			
		Particulates	0.12~~ng~~ mg		
		Gaseo~~n~~us	26~~ng~~ mg		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends.	0.096 lb/ton	-	130
		Ferroalloy furnaces		-	108
		Open silicon metal			
		gas phase	14~~ng~~ ug/m^3		
		emissions	9.3gms/hr		
		Covered Ferrosilicon furnace, secondary fume			
		gas phase	9~~ng~~ ug/m^3		
		emissions	6gms/hr		
		In carbon paper (~~ng~~ ug/ sheet)	4.0	–	113

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Fluorene	86-73-7				

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
7H-Benz (de) Anthracene -7-one	82-05-3	Coal fly ash, tentative	identified		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Benz(a) Anthracene -7,12 - dione	2498-66-0	Coal fly ash, tentative	Identafied	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
9-Fluorenone	486-25-9	Diesel Particulate Extract (Fluorenones)	4.8ppb	-	10
		Oldsmobile (1978) diesel engine particulate extracts (fluorenone)	Identified	-	33
		Wood stove with a catalytic combustor, condensable fraction (as fluonenone)		-	75
		Before the combustor	35ug/of organics		
		After the combustor	15ug/of organics		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends, as fluorenone.	0.042 lb/ton	-	130
		Coal fly ash, tentative	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Indeno (1,2,3-cd) Pyrene	193-39-5	Power Plant Boilers		-	21
		Boiler fined by heavy fuel oil without flue gas cleaning systems.	Less than 0.5~~ng~~ug/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 0.1~~ng~~ug/m^3	-	21
		Boiler fired by coal, equipped with baghouse filter for cleaning flue gas.	Less than 0.07~~ng~~ug/m^3	-	21
		Boiler fired by coal; inefficient combustion equipped with baghouse filter.	5~~ng~~ug/m^3	-	21
		Gasoline vehicle, FTP test, cold start.	1.3~~ng~~ug/km	-	7
		Gasoline - catalyst vehicle FTP test, cold start.	0.3~~ng~~ug/km	-	7
		Gasoline - 15% methanol FTP test, cold start.	1.7~~ng~~ug/km	-	7
		Diesel vehicle, FTP test, cold start.	14~~ng~~ug/km	-	7
		Ha~~r~~nd stoked residential stove, coal briquettes, combustion, flue gas.	13.5~~ng~~ug/m^3	-	12
		Laboratory coal gasification (blends of different coals)	0.2ng/J	-	28
		coal emission	$<$ 0.007 x 10^{-5}ng/J	-	28
		Fluidized bed coal combustion (two samples)	(0.25, 0.25) x 10^{-5} ng/J	-	28
		Woodheaters (as Indeno (1,2,3-cd) pyrene/ Benzo(ghi) perylene)		-	53
		Heater 1 - nonbaffled airtight circulator.	0.0043 gm/kg wood		
		Nonbaffled airtight catalytic radiant heater.	0.0003 gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
I Indeno (~~112,3-cd~~) (1,2,3-cd) pyrene	193-39-5	Retrofit add on catalytic combustor added to heater 1.	0.0020 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst	0.0013 gm/kg wood		
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46
		Wood stove, varying burn modes, side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to 6.79 kg			
		Seasoned oak (low-high)			
		particulates	0.17-15~~ng~~ mg		
		gaseons	0.15-3.9/~~ng~~ mg		
		Green pine (side draft)			
		particulates	38mg		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends.	0.008 lb/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests (as indenopyrene)		-	79
		high altitude test	0.0010g/kg		
		Electric power plant boiler, medium sulfur eastern coal, tangentially fired; equipped with electrostatic precipitator, USA	0.2-0.4~~ng~~ ug 0.1-1.7~~ng~~ ug	-	98
		Amount in unknown sample size, low-high ranges, 3 test results.			

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Indeno (1,2,3-cd)	193-39-5	Hot water boiler - combustion of wood and peat, relative to benzo(ghi) perylene		-	99
		wood	0.8		
		peat	1.5		
		Residential wood stove (ng/kg dry fuel burned)		-	126
		Birch: normal combustion	415		
		Birch: starved combustion	170		
		Spruce: Normal combustion	33		
		Spruce: Starved combustion	~~921~~ 291		
		Residential charcoal stove (~~ng~~ μg/kg dry fuel burned) to be reduced by a factor of 3 - 4 for comparison with wood.	0.2		
		Incarbon paper (~~ng~~ μg/sheet)	20.7		113

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1-Methyl naphthalene	90-12-0	Coal liquefaction pilot plant, USA	-	-	15
		Extract of soot collected from flames, benzene - air mixture fuel, % extract fraction range in 40^{o}c to 200^{o}c (as methyl naphthalene)	39-2.0	-	31
		Solvent extract of emissions collected from flames, ~~Backed~~ fuelled by hydrocarbon(s) air mixture (as % amounts)			
		Toluene	1.6	-	31
		Toluene/Heptane	1.58	-	31
		Heptane	0.71	-	31
		Wood heaters: (as naphthalene, methyl-naphthalenes) phenylnaphthalenes).		-	53
		Heater 1, a nonbaffled airtight circulator.	0.1228gm/ kg wood		
		A nonbaffled airtight catalytic radiant unit.	0.0228gm/ kg wood		
		Retrofit, add on catalytic combustor added to heater 1.	0.1036 gm/kg wood		
		A baffled airtight catalytic circulator with metal base catalyst.	0.0866 gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0407 ~~0.12407~~ gm/kg wood		
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46
		Pilot plant coal gasification gas, water soluble components, subbituminous coal, peat and lignite coal, as methylnaphthalene.	Identified	-	128

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
12 1-Methyl naphthalene	90-12-0	Pilot plant coal gasification; base-neutral water extract of raw gas,		-	128
		Lignite gas	2.6mg/1		
		Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction, condensible fractions of stack gases.	0.2749 and 0.3510 mg/kg wood	-	73
		Wood stove with a catalytic combustor of condensable fraction (as C_1-naphthalene)		-	75
		Before the combustor	119ug/of organics		
		After the combustor	9ug/of organics		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends, as methylnaphthalenes	0.44 lb/ton	-	130
		Wood combustions, nonbaffled stove burning seasoned oak, low/high altitude tests as methylnaphthalene		-	79
		high altitude test	0.0024 g/kg		
		In carbon paper (ug/sheet)	1-9		113
		Coal fly ash tentative identification as methylnaphthalenes	Identifed		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
2-Methyl naphthalene	91-57-6	Coal liquefaction pilot plant, USA	-	-	15
		Extract of soot collected from flames, benzene - air mixture fuel, % extract fraction range in 40°c to 200°c (as methylnaphthalene)	39-2.0	-	31
		Solvent extract of emissions from flames fueled by hydrocarbon(s) - air mixture (as % amounts)	-	-	31
		Toluene	2.1	-	31
		Toluene/Heptane	1.95	-	31
		Haptane	0.88	-	31
		Wood heaters: (as naphthalene, methyl-naphthalene and phenyl-naphthalenes)		-	53
		Heater 1, nonbaffled airtight circulator.	0.1228g/ kg wood		
		A nonbaffled airtight catalytic radiant unit.	0.0228gm gm/kg wood		
		Retrofit, add on catalytic combustor added to heater 1.	0.1036gm/ kg wood		
		a baffled airtight catalytic circulator with metal base catalyst.	0.0866 gm/kg wood		
		Airtight unit with secondary combustion provisions.	0.0407 gm/kg wood		
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
2-Methyl naphthalene	91-57-6	Pilot plant coal gasification gas, water soluble components subbituminous coal, peat and lignite as methylnaphthalene.	Identified	-	128
		Pilot plant coal gasification base-neutral water extract of ~~new~~ Low gas, lignite coal.	1.2mg/l	-	128
		Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction, condensable fraction of st~~o~~ack gases.	0.4936 and 0.7169 mg~~ng~~/kg wood	-	73
		Wood stove with a catalytic combustor, condensable fraction, as C_1-naphthalene. Before the combustor After the combustor	 119ug~~ng~~/of organics 9~~ng~~ug/of organics	-	75
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends, as methyl naphthalenes.	0.44 lb/ton		
		Wood combustion, nonbaffled stove burning seasoned oak, low/high altitude test as methylnaphthalene high altitude test	 0.0024g/kg	-	79
		In carbon paper (~~ng~~ug/sheet)	2.1	—	113
		Coal fly ash, as methyl naphthalenes, tentative	Identified	—	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Naphthalene	091-20-3	Aluminum Plant	-	-	15
		Coal Liquefaction Pilot Plant, USA	-	-	15

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Naphthalene	091-20-3	Power plant boilers			
		Boiler fired by heavy fuel oil without flue gas cleaning system.	0.5~~ng~~ug/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	~1~~ng~~ug/m^3	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	5~~ng~~ug/m^3	-	21
		Boiler fired by coal Inefficient combustion equipped with baghouse filter.	7000~~ng~~ug/m^3	-	21
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		Extracts of soot collected from flames benze - air mixture, fuel, % extract fraction range in 40°c to 200°c.	56-0.11	-	31
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)		-	31
		Toluene	8.8	-	31
		Toluene/Heptane	11.11	-	31
		Heptane	13.62	-	31
		Laboratory coal gasification (blends of different coals)	66ng/J	-	28
		Coal combustion	1.9×10^{-5} ng/Joule coal energy	-	28

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Naphthalene	091-20-3	Wood heaters (as naphthalene, methyl-naphthalene and phenyl-naphthalenes)		-	53
		Heater 1, nonbaffled airtight circulator	0.1228g/kg wood		
		Nonbaffled airtight catalytic radiant unit.	0.0228g/kg wood		
		Retrofit add on catalytic combustor added to heater 1.	0.1036g/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0866g/kg		
		Air tight unit designed to provide secondary combustion features.	0.0407g/kg wood		
		Petroleum road asphalts simulated atmospheric and lighting conditions.	Identified	-	46
		Pilot plant coal gasification gas, water soluble components, subbituminous coal, peat and lignite.	Identified	-	128
		Pilot plant coal gasification base-neutral water extract of raw gas		-	128
		Subbituminous coal	37.1mg/1		
		Lignite coal	100.3mg/1		
		Airtight woodburning stove, seasoned oak, two sizes, two burn rates, polar fraction, condensible fractions of st~~o~~ack gases	1.0927 and 14.1665mg/kg wood	-	73

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Naphthalene	091-20-3	Woodstove, varying burn modes - side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to 6.79 kg.		-	129
		Seasoned oak (low-high)			
		Particulates	0.07-1.2mg		
		Gaseous	11-62mg		
		Green pine			
		Particulates	0.22mg		
		Gaseous	80mg		
		Wood stove, equipped with a catalytic combustor, condensable fraction		-	75
		Before the combustor	275~~mg~~ug/of organics		
		After the combustor	10~~mg~~ug/of organics		
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends.	0.56 lb/ton	-	130
		Ferroalloy furnaces			
		Silicon metal furnace open, gas phase emissions	957~~mg~~ug/m^3 629gms/hr		108
		Covered ferrosilicon furnace			
		gas phase emissions	433~~mg~~ug/m^3 279gms/hr		
		In carbon paper (~~ng~~ug/sheet)	5.0		113
		Coal fly ash (tentative)	Identified		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
9-Nitro anthracene	602-60-8	Diesel Particulate Extract (Nitro anthracenes and pheranthrenes)	0.71ppb	-	10

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
3-Nitro fluoranthene	892-21-7	Diesel Particulate Extract (Nitro fluoranthene)	0.05ppb	-	10
		1978 Oldsmobile diesel engine particulates extract (as nitro-fluoranthene)	Identified	-	33
		1981 diesel passenger car exhausts	Identified	-	65
		Coal fly ash, tentative as nitrofluoranthenes and nitropyrenes.	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
8-Nitro fluoranthene	13177-32-7	Diesel Particulate Extract (Nitrofluoranthenes)	0.05ppb	-	10
		1978 Oldsmobile diesel engine particulates extract (as nitro-fluoranthene)	Identified	-	33
		1981 diesel passenger car exhausts	Identified	-	65
		Coal fly ash, tentative as nitrofluoranthenes and nitropyrenes.	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
a [illegible]-Nitro Pheranthrene	-	Diesel Particulate Extract, Nitro(anthracenes and phenanthrenes)	0.71ppb	-	10
		Coal fly ash, tentative as nitrophenanthrenes.	tentative	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
b-Nitro pheranthrene	68455-92-5	Diesel Particulate Extract Nitro(anthracenes and phenanthrenes)	0.71ppb	-	10
		Coal fly ash, tentative as nitrophenanthrenes.	Identified		121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
C-Nitro phenanthrene	-	Diesel Particulate Extract Nitro(anthracenes and phenanthrenes)	0.71ppb	-	10
		Coal fly ash, tentative as nitrophenanthrenes.	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
6-Nitro benzo(a) fluorene	-	Diesel Particulate Extract. (Nitrofluorenes)	0.34ppb	-	10
		Two diesel vehicles FTP test.	<0.1~~ng~~μg/km	-	7
		Two gasoline vehicles FTP test.	0.9~~ng~~μg/km		
		Two gasoline catalyst vehicles, FTP test	< 0.1~~ng~~μg/km	-	7
		1978-1980 diesel cars exhaust particulates	<0.1 - 1.8 ng/mg particulates	-	71
		Coal fly ash, tentative as nitromethylpyrenes and nitrobenzofluorenes.	Identifed	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1-Nitro naphthalene	86-57-7	Coal fly ash, tentative as nitronaphthalenes.	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
6-Nitro benzo(a) pyrene	63041-90-7	Coal fly ash, tentative as Nitrobenzo fluoranthenes and Nitrobenzopyrenes.	Identified	-	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
1-Nitropyrene	5522-43-0	Diesel Particulate Extract (Nitropyrenes)	1.5ppb	-	10
		Two diesel vehicles, FTP test	2-~~ng~~ ug/km	-	7
		Two gasoline vehicles FTP test	0.1~~ng~~ ug/km	-	7
		Two gasoline catalyst vehicles, FTP test	<0.1-~~ng~~ ug/km	-	7
		1978 Oldsmobile diesel engine particulates extract (as nitropyrene)	Identified	-	33
		1981 diesel passenger car exhausts	Identified	-	65
		Carbon black (as nitropyrene)	Identified	-	70
		1978-1980 diesel cars exhaust particulates	6.4-9.8ng/mg particulates	-	71
		Coal fly ash, tentative as nitrofluoranthenes and nitropyrenes.	Identified	—	121

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Oxygenated PAHs		1978 Oldsmobile diesel engine particulates extract	Identified	-	33

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		Wood stove, varying burn modes, side draft up draft, down draft, high turbulence draft, (Low-high)	89-390mg/m^3	-	129
		Coal combustion residential bituminous, subbituminous, washed and unwashed blends as POMS.		-	130
		Boiler, washed, unwashed range	0.26-0.58 lb/ton		
		Furnace, washed, unwashed	.036-1070 lb/ton		
		Boiler, varying coal types, bituminous and subbituminous (low-high)	0.025-0.6 lb/ton		
		Wood combustion, non-baffled stove burning seasoned oak low/high altitude tests		-	79
		POM emission factor			
		low altitude test	0.2g/kg		
		high altitude test	0.05g/kg		
		Utility Boilers: as POMS ASF: ambient severity factor defined as ratio of maximum ground level concentration calculated to the level at which a potential environmental hazard exists.	←	-	95
		Resid~~ential~~ual - tangential firing Emission factor	0.0047ng/J		
		Resid~~ential~~ual Oil, wall firing Emission factor	0.0047ng/J		
		Bituminous coal fired, pulverized dry bottom Emission factor	0.0039ng/J		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		Bituminous coal fired, pulverized wet bottom Emission factor	0.042ng/J		
		Bituminous coal fired, cyclone equipped Emission factor	0.0059ng/J		
		Bituminous coal fired, ~~cyclone~~ stokers equipped Emission factor	0.015ng/J		
		Commercial/institutional Combustion sources Emission factors (POMS)		-	95
		Gas fired boilers	0.010ng/J		
		Distillate Oil fired boilers	0.020ng/J		
		Residual Oil fired boilers	0.044ng/J		
		Bituminous pulverized dry bottom	0.002ng/J		
		Bituminous stokers	0.5ng/J		
		Anthracite stokers	0.003ng/J		
		Wood stokers	26ng/J		
		Oil fired reciprocating engine	0.430ng/J		
		Vehicle engines run on gasoline, leaded	2-9~~ng~~ug/km	-	8
		Catalyst equipped run on gasoline	35-170~~ng~~ug/km	-	8
		Gasohol	35-170~~ng~~ug/km	-	8
		diesel	50-1000~~ng~~ug/km	-	8
		95% methanol	2-9~~ng~~ug/km	-	8
		1978 Oldsmobile diesel engine particulates extract.	Identified	-	33
		Steel Mills, Coke Production, Ontario	Emissions 52% of total PAH emissions	1977	30

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		Wood heaters, Total PAH range		-	53
		Heater 1 - non-baffled airtight circulator.	0.0074-0.5810gms/ kg wood burned		
		Nonbaffled airtight catalytic radiant heaters.	0.0056-0.1340gm/ kg wood burned		
		Retrofit add on catalytic combustor added to heater 1	0.0193-0.7370gm/ kg wood burned		
		Baffled airtight catalytic circulator with metal base catalyst	0.0931-0.2323gm kg/wood burned		
		Airtight unit with secondary combustion provisions	0.1082-0.43gm/kg wood burned		
		PAH range with variations in excess air with the above 5 heaters.	0.0056-0.737 gm/kg wood		
		Petroleum raod asphalts simulated atmospheric and lighting conditions			
		Varying temperature, in presence of irradiation. range.	1363-3008 ng/m^3	-	46
		Varying temperature, in absence of light	7961 - 12833ng/m^3	-	46
		Varying temperature humidity and lighting conditions	39.7 - 13.333ng/m^3	-	46
		Airtight woodburning stove, two sizes, two burn rates, as higher molecular weight POMS	0.25 and 1.26mg/kg wood	-	73
		Baffled stove, seasoned oak, as higher molecular weight POMS	39.2~~ng~~mg/kg wood	-	73

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		Wood combustion, Total PAH (unspecified units)		-	74
		Furnace with prechamber wood chips	80 and 530		
		Fireplace, wood chips	2900 and 31000		
		Furnace, wood	26000, 160,000 36,000		
		Modified fireplace, wood	8200,9600, 5900,32000		
		Airtight stove, wood	5200,5100, 6000,630000 140000		
		One underfired stoker unit with wood fuel, one test.	15000pg/J	-	95
		One underfired stoker unit with bituminous coal, one test.	26000 ~~2600~~pg/J		
		One oil fired (dual fired) reciprocating engines, range.	100 to 800 pg/J	-	95
		Industrial Combustion Sources POMS Emission factors			
		Distillate fired boilers	0.015ng/J		
		Residual oil fired boilers	<0.001ng/J		
		Coal fired bituminous pulverized wet bottom boilers	0.003ng/J		
		Coal fired bituminous stokers	0.18ng/J		
		Wood fired boilers	0.18ng/J		
		Bituminous stokers	180pg/J		
		Wood fired boilers	210pg/J		
		Pulverized coal fired laboratory boiler, equipped with a fabric baghouse filter. POMS other than anthracene, phenanthrene, fluoranthene, pyrene, methylpyrene and methylanthracene	~1-1.5ug/m^3	-	98

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		low-high (6 tests)			
		Coal combustion, combustor test results, dependent on sampling procedure, low/high range.	22-200~~mg~~μg/m^3	-	98
		Wall fired boiler fired by low sulfur coal, equipped with baghouse filter inlet, outlet, baghouse concentration ranges.		-	98
		baghouse inlet	5-10~~mg~~μg/m^3 one value at 30.5~~mg~~μg/m^3		
		baghouse outlet	4-26.5~~mg~~μg/m^3		
		Foundries, Ontario (as % of total suspended particulates)			109
		Personal samples, mean range	0.01-0.18%		
		Personal samples, maximum range	0.06% - 0.99%		
		Area samples, mean	0.52%		
		Area samples, maximum	4.10%		
		Residential wood stove			128
		Birch: normal combustion	20.9mg/kg dry fuel		
		Birch: Starved combustion	20.1mg/kg dry fuel		
		Spruce: Normal combustion	2.6mg/kg dry fuel		
		Spruce: Starved combustion	32.3mg/kg dry fuel		
		Residential Chracoal stove, Normal combustion, data to be reduced by a factor of 3 to 4 for comparison in the wood.	0.095mg/kg dry fuel		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH		Residential wood stove ~~mg~~ ug/kg dry fuel burned (as total PAH)			126
		Birch: Normal combustion	20870		
		Birch: Starved combustion	20085		
		Spruce: Normal combustion	2560		
		Spruce: Starved combustion	32270		
		Residential charcoal stove (~~mg~~ ug/kg dry fuel burned) to be reduced by a factor of 3-4 for comparison with wood (as total PAH)	95.1		
PAH Soluble Materials		Steel Plant, UK Personal exposures benzene soluble materials		-	106
		mean low-high range	0.5-2.2mg/m^3		
		plant mean range	0.3-11.4mg/m^3		
		Plants, USA mean low-high range	0.9-3.2mg/m^3		
		Refractories plant, Clearfield, Pennsylvania USA		-	88
		Benzene soluble fraction of coal tar products.	0.03 to 1.42 mg/m^3		
		6 samples, cyclohexane solubel fractions of coal tar products.	$>$0.1mg/m^3		
		4 samples, coal tar pitch volatiles, benzene soluble fractions.	$>$0.2mg/m^3		
		Personal air samples Benzene solubles, low-high range	0.03-1.42mg/m^3		
		Steel Plant, Pueblo Colorado, USA Coal tar pitch volatiles	0.07 to 0.13mg/m^3	-	89

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
PAH Soluble Materials		Aluminum Plant, Ravenswood, West Virgina USA		-	90
		Personal samples Coal tar pitch volatiles, 14 out of 46 samples.	>0.1mg/m^3		
		Benzene Soluble Fraction	0.06mg/m^3	April 1979	
			0.11mg/m^3	July 1978	
		27 Personal samples, benzene soluble fraction, low-high range mean	nondetectable to 0.14mg/m^3 0.06mg/m^3	April 1979.	
		Personal samples benzene soluble fraction, low-high range	0.02-0.37 mg/m^3	July 1978	
		Personal 8 out of 27 samples	>0.1mg/m^3	April 1979	90
		Personal samples, all	<0.2mg/m^3	April 1979	
		Aluminum Plant Chalmette, Louisiana USA		April 6-7,1978	91
		Carbon plant personal samples benzene soluble fraction	0.42 and 0.44mg/m^3		
		Benzene soluble fraction of particulates, in plant location	0.11mg/m^3 to 0.20 mg/m^3		
		Benzene soluble fraction, in plant, low-high range.	<0.03 - 0.44 mg/m^3		
		Background medical building	0.06 - 0.11mg/m^3		
		Background	<0.03 - 0.14mg/m^3		
		Asphalt Shingles plant Pittsburgh, California USA			
		Asphalt fumes cyclohexane soluble	0.37-10.0 mg/m^3	April 19, 1977	93

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
		fraction, low-high range	0.21 - 21 mg/m^3	August 4 1977	93
		Coke Plant, Steel Plant Follansbee, West Virginia, USA		-	94
		Coal tar pitch, Volatiles, benzene soluble fraction;			
		Booster room •	0.31mg/m^3		
		Desulfurization Control room •	none detected		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Perylene	198-55-0	Pilot plant ~~and~~ coal gasification, base-neutral water extract of raw gas Subbituminous coal Lignite coal	 0.6mg/l 0.6mg/l	-	128
		Wood stove, varying burn modes - side draft, up draft, down draft, high turbulence draft. Total wood burned 6.33 to 6.79 kg Seasoned oak (low-high) Particulates Gaseons Green pine (side draft) Particulates Gaseons	 0.09-0.51mg 0.1-0.68mg 1.8mg 0.09mg	-	129
		Wood stove with a catalytic combustor, condensable fraction Before the combustor After the combustor	 28~~mg~~ug/of organics Below detection limit	-	75
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends as benzopyrene(s) and perylene	0.012 lb/ton	-	130
		Utility boilers, residual and gas fired. ASF: Ambiant severity factor defined as the ratio of maximum ground level concentration ~~collected~~ calculated to the level at which a potential environmental hazard exists. Data as benzopyrenes and perylenes.		-	95

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Perylene	198-55-0	Residual oil tangential firing			
		Emission factor	6.25×10^{-7} ng/J		
		ASF	0.014		
		Residual oil, wall firing			
		Emission factor	6.25×10^{-7} ng/J		
		ASF	0.005		
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA Amount in unknown sample size, low-high ranges, 3 test results.	0.2~~ng~~ µg 0.1-0.3~~ng~~ µg	-	98
		Diesel engine, a composite of ten commercial No. 2 diesel fuels.	Identified	-	99
		Anthracite Coal briquettes, assuming BaP emissions = 100	225		3
		Anthracite Coal, assuming BaP emissions = 100	200		3
		Brown coal, assuming BaP emissions = 100	250		3
		Coal, assuming BaP emissions = 100	180		3
		Automobile exhaust condensate, assuming BaP emissions = 100	15		3
		Ha~~r~~nd stoked residential stove, coal briquettes combustion, flue gas.	5~~ng~~ µg/m^3	-	12
		Oil fired central heating system, light oil, oil burner.	5ng/kg fuel	-	12
		Diesel engine, ECE test	12ng/liter fuel	-	12
		Engine, gasoline, ECE test	14~~ng~~ µg/liter fuel	-	12

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Perylene	198-55-0	1978 Oldsmobile diesel engine particulates extracts.	Identified	-	33
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) -air mixture (as % amounts)			
		Toluene	0.20	-	31
		Toluene/Heptane	0.05	-	31
		Heptane	0.06	-	31
		Coke production, Steel Mill, Ontario	Identified	1977-78	30
		Pilot plant foundry - air samples, Finland	detected	-	29
		Iron foundries, Finland airborne particulate matter	detected	-	29
		Pyrolysis of iron foundry molding sands Finland (as % of PAHS, two samples)	0.09% and 1.2%	-	29
		Wood combustion (as benzopyrenes/perylene)		-	26
		Zero clearance fireplace			
		Seasoned oak	<0.0014gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0083gm/kg wood		
		Green pine	0.0116mg/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0084gm/kg wood		
		Green pine	0.0094gm/kg wood		
		Woodstoves burning wood including oak, maple and pine, Canada.	trace ug ~~ng~~/kg fuel	-	55

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Perylene	198-55-0	Woodburning furnace emissions, Canada	trace	-	55
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value.	$<$1-70 ng/m^3	-	51
		Hot water boiler - Combustion of wood and peat, relative to benzo(ghi)perylene		-	99
		wood	0.2		
		peat	0.2		
		Foundries, Ontario as perylene and benzo(k) fluoranthene			109
		Personal samples			
		maximum	4.76~~ng~~ug/m^3		
		Area samples			
		maximum	11.85~~ng~~ug/m^3		
		Residential wood stove (~~ng~~ug/kg/dry fuel burned)		-	126
		Birch: Normal combustion	274		
		Birch: Starved combustion	24		
		Spruce: Normal combustion	23		
		Spruce: Starved combustion	38		
		Residential charcoal stove(~~ng~~ug/kg/dry fuel burned) to be reduced by a factor of 3-4 for comparison with wood.	0.3		
		In carbon paper (~~ng~~ug/sheet)	11.8		113

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pheranthrene	85-01-8	Pilot plant coal gasification. base neutral water extract of raw gas Subbituminous coal Lignite coal	 19.7mg/1 1.7mg/1		
		Airtight woodburning stove, seasoned oak two sizes, two burn rates, as phenanthrene/anthracene	0.88 and 2.3mg/kg wood	-	73
		Baffled stove, seasoned oak, as phenanthrene/anthracene	74.5~~ng~~ mg/kg/wood	-	73
		Airtight wood burning stove, seasoned oak, polar fraction, condensable portion of stack gases as C_1-anthracene/phenanthrene	0.0325mg/kg wood	-	73
		As phenanthrene	0.8203 and 2.2974 mg/kg wood		
		As phenanthrene in particulates	0.0596 mg/kg wood		
		Wood stove, varying burn modes, side draft, up draft, down draft, high turbulence draft, Total wood burned 6.33 to 6.79 kg. Seasoned oak (low-high) Particulates Gaseo~~n~~us Green pine Particulates Gaseons	 0.24-0.99mg 20-96mg 2.2mg 100mg	-	129
		Wood stove with a catalytic combustor condensable fraction, Before the combustor After the combustor	 78~~ng~~ µg/of organics 24~~ng~~ µg/of organics	-	75
		Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed blends.		-	130

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	as methylanthracenes and phenanthrene	0.030 lb/ton		
		as dimethylanthracenes and phenanthrenes	0.02 lb/ton		
		Wood combustion, non-baffled stove burning seasoned oak low/high altitude tests As anthracene/ phenanthrene		-	79
		low altitude	0.0618g/kg		
		high altitude	0.100g/kg		
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests as dibenzanthracenes/ phenanthrenes		-	79
		low altitude test	0.0010g/kg		
		high altitude test	0.0003g/kg		
		Wood combustion, (as anthracene and phenanthrene) Zero clearance fireplace		-	26
		Seasoned oak	0.0082gm/kg wood		
		Green pine	0.0069gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0745gm/kg wood		
		Green pine	0.1463gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0618gm/kg wood		
		Green pine	0.1034gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	(as dibenzanthracene/ phenanthrenes)			
		Zero clearance fireplace			
		Green pine	0.0001gm/kg wood		
		Airtight baffled stove			
		Seasoned oak	0.0007gm/kg wood		
		Green pine	0.0014gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0010gm/kg wood		
		Green pine	0.0005gm/kg wood		
		Laboratory coal gasification (blends of differnt coals)	18ng/J	-	28
		Coal Combustion (two samples)	$(3.1;1100)\times10^{-5}$ ng/Joule coal energy	-	28
		Wood stoves burning wood including oak maple and pine, Canada.	30-1574 ug ~~mg~~/kg fuel	-	55
		Wood burning furnace emissions, Canada	8-120 ug ~~mg~~/gm particulates		55
		Wood heaters (as phenanthrene and anthracene)		-	53
		Heater 1 - nonbaffled airtight circulator	0.0412 gm/kg wood		
		Nonbaffled airtight catalytic radiant heater	0.0103 gm/kg wood		
		Retrofit add on catalytic combustor added to heater	0.0372 gm/kg wood		
		Baffled airtight catalytic circulator with metal base catalyst.	0.0297 gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	Airtight unit with secondary combustion provisions.	0.0140 gm/kg wood		
		Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value	688-432000 ng/m^3	-	51
		Wood combustion	5800~~ng~~ug/ kg wood	-	59
		Pilot plant coal gasification, water soluble components, subbituminous coal, peat and lignite coal or anthracene.	Identified	-	128
		Ferroalloy plants	-	-	15
		Coal liquefaction pilot plant, USA	-	-	15
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		1978 Oldsmobile diesel engine particulates extract.	Identifed	-	33
		Extract of soot collected from flames, benzene-air mixure fuel, % fraction range in 40^{o}c to 200^{o}c.	90-4.6	-	31
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)		-	31
		Toluene	4.5	-	31
		Toluene/Heptane	3.51	-	31
		Heptane	9.12	-	31
		Pilot plant foundry - air samples, Finland	detected	-	29
		Iron foundries, Finland airborne particulate matter.	detected	-	29
		Pyrolysis of iron foundry molding sands, Finland (as % of 10 PAHs, two samples)	46% and 36%	-	29

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	Power Plant boilers. Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5 ug/m^{-3}	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	0.2~~ng~~ug/m^3	-	21
		Boiler fired by coal Inefficient combustion equipped with baghouse filter.	600~~ng~~ug/m^3	-	21
		Boiler fired by coal equipped with baghouse filter for cleaning flue gas.	0.2~~ng~~ug/~~m3~~m^3	-	21
		Diesel particulate extract (Phenanthrenes and Anthracenes)	1.1ppb	-	10
		Vehicle in a ECE test	288~~ng~~ug/k~~g~~m	-	7
		Gasoline vehicle, FTP test, cold start	1.7~~ng~~ug/km	-	7
		Gasoline - Catalyst vehicle, FTP test, cold start.	0.06~~ng~~ug/km	-	7
		Gasoline, 15% methanol FTP test, cold start.	2.3~~ng~~ug/km	-	7
		Diesel vehicle, FTP test, cold start	223~~ng~~ug/~~kg~~km		
		Incinerator - municipal and other	Identified	-	99
		Hot water boiler - combustion of wood and peat, relative to benzo(ghi) perylene		-	99
		wood	55		
		peat	45		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	Residential wood stove (~~ng~~ ug/kg dry fuel burned)			126
		Birch: normal combustion	5821		
		Birch: starved combustion	5060		
		Spruce: normal combustion	834		
		Spruce: starved combustion	8390		
		Residential charcoal stove; to be reduced by a factor of 3 to 4 for comparison with wood. (~~ng~~ ug/kg dry fuel burned).	45-6		
		In carbon paper (~~ng~~ ug/sheet)	50.8		113
		Coal fly ash (tentative)	Identified		121
		Fly ash extract as % extract	0.87 ± 0.05 %		121
		Pulverized coal fired laboratory boiler equipped with baghouse filter. low-high range (6 tests) as anthracene/phenanthrene	12-110 ng/m^3		98
		Low sulfur ~~wass~~ wall fired boiler, equipped with baghouse filter as anthracene/phenanthrene			
		Baghouse inlet	1.5, 1.5, 4.6 ~~ng~~ ug/m^3		
		Baghouse outlet	1.7, 5 14.8 ~~ng~~ ug/m^3		
		Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA (as anthracene/phenanthrene)	1.0-372.3 ~~ng~~ ug 0.2-190.4 ~~ng~~ ug 7.0-635.1 ~~ng~~ ug	-	98
		Amount in unknown sample size, low-high ranges, 3 test results			
		6 test results	1.0-37.5 ~~ng~~ ug/m^3		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	Diesel engine, a composite of ten commercial No.2 diesel fuels.	Identified	-	99
		Open burning - refuse burning.	Identified	-	99

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Coal combustion, residential bituminous coal, subbituminous coal, washed, unwashed, blends as methylfluoranthenes and pyrenes	0.018 lb/ton 0.008 lb/ton	-	130
		Wood combustion, non-baffled stove burning seasoned oak, low/high altitude tests low altitude test high altitude test	 0.0169g/kg 0.0026g/kg	-	79
		Refractory cements plants, USA	Not detected to 0.87 ~~ng~~ ug/m^3	6/27/79 9/26-27/79	88
		Personal air samples low-high range	<0.13 -0.87 ~~ng~~ ug/m^3	6/26-27/79	
		Aluminum Plant, USA Range Mean	 Not detected to 32 ~~ng~~ ug/m^3 1.6 ~~ng~~ ug/m^3	1979	
		Aluminum Plant, chalmette Louisiana, USA Range	<0.27 -15.00 ~~ng~~ ug/m^3	4/6-7/78	91
		Background	<0.35 and 0.57 ~~ng~~ ug/m^3	4/6-7/78	91
		Asphalt shingles plant Pittsburgh, California USA Area sample	0.14 ~~ng~~ ug/m^3	8/4/77	93
		Pulverized coal fired laboratory boiler with a fabric baghouse filter, low-high range (6 tests)	2.5-17.5 ~~ng~~ ug/m^3	-	98
		Low sulfur coal wall fired boiler, equipped with a baghouse filter baghouse filter inlet baghouse filter outlet	0.25 0.25,0.25 ~~ng~~ ug/m^3 1.0,0.3,0.3 ~~ng~~ ug/m^3	-	98

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Electric power plant boiler, medium sulfur eastern coal tangentially fired, equipped with electrostatic precipitator, USA			
		Amount in unknown samples size, low-high ranges, 3 test results	0.2-105.9 ug 0.1-39.7 ug 0.3-66.5 ug		
		4 test results	0.5-7 ug/m^3		
		Diesel engine, a composite of 10 commercial No. 2 diesel fuels	Identified	–	99
		Open burning - refuse burning	Identified	–	99
		Incinerator - municipal and other	Identified	–	99
		Hot water boiler, combustion of wood and peat relative to benzo(ghi) Perylene		-	99
		wood	19		
		peat	16		
		Solvent extract of emissions collected from flames fueled by hydrocarbon(s) - air mixture (as % amounts)		-	31
		Toluene	2.0	-	31
		Toluene/Heptane	2.05	-	31
		Heptane	6.67	-	31
		Pilot plant foundry, air samples, Finland	detected	-	29
		Iron foundries, airborne particulate matter, Finland	detected	-	29
		Pyrolysis of iron foundry molding sands, Finland (as % of 10 PAHs, two samples)	18% and 6%	-	29
		Wood combustion			
		Zero clearance fireplace			
		Seasoned oak	<0.0014gm/kg wood		
		Green pine	0.0016gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Airtight baffled stove			
		Seasoned oak	0.0156gm/kg wood		
		Green pine	0.0240gm/kg wood		
		Airtight nonbaffled stove			
		Seasoned oak	0.0169gm/kg wood		
		Green pine	0.0013gm/kg wood		
		Laboratory coal gasifier (blends of different coals)	12ng/J	-	28
		Coal combustion (two samples)	(11.4,1100) x10^{-5}ng/Joule Coal energy	-	28
		Fluidized bed coal combustion (two samples)	(0.3,0.33)x 10^{-5}ng/J	-	28
		Wood stoves burning wood including oak, maple and pine, Canada	18-508 ug~~ng~~/kg fuel	-	55
		Woodburning furnace emissions, Canada	trace - 45 ug~~ng~~/gm particulates	-	55
		Woodheaters:		-	53
		Heater 1 - nonbaffled airtight circulation	0.0069 gm/kg wood		
		Nonbaffled airtight catalytic radiant heater.	0.0017 gm/kg wood		
		Redtrofit add on catalytic combustor added to heater 1	0.0062 gm/kg wood		
		Baffled airtight catalytic with metal base catalyst	0.0043 gm/kg wood		
		Airtight heater with secondary combustion provisions.	0.0020 gm/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Power plant, laboratory coal fired fluidized bed, range, temperature variation at the high value.	57-48,900 ng/m^3	-	51
		Petroleum road asphalts simulated atmospheric and lighting conditions	Identified	-	46
		Wood combustion	2700~~ng~~ug/ kg wood	-	59
		Power Plant Boilers. Boiler fired by heavy fuel oil without flue gas cleaning system.	Less than 0.5~~ng~~ug/m^3	-	21
		Boiler fired by pulverized coal equipped with electrostatic precipitator.	Less than 0.2~~ng~~ug/m^3	-	21
		Boiler fired by coal, equipped with baghouse filter for cleaning flue gas.	0.07~~ng~~ug/m^3	-	21
		Boiler fired by coal inefficient combustion equipped with baghouse filter.	200~~ng~~ug/m^3	-	21
		Diesel particulate Extract	3.1ppb	-	10
		Vehicles in an ECE test	184~~ng~~ug/km	-	7
		Volkswagon Rabbit (1978) diesel fuel, FTP test,	70~~ng~~ug/km	-	7
		Golf (1979), gasoline FTP test	60~~ng~~ug/km	-	7
		Fiat 126, ECE test	90~~ng~~ug/km	-	7
		Fiat 128, ECE test	758~~ng~~ug/km	-	7
		Japanese City Mode Driving cycle mean of 5 vehicles	54~~ng~~ug/km	-	7
		Two diesel vehicles, FTP test	15~~ng~~ug/km	-	7
		Two gasoline vehicles, FTP test	8~~ng~~ug/km	-	7
		Two gasoline catalyst vehicles, FTP test	0.7~~ng~~ug/km	-	7
		Gasoline vehicle, FTP test, cold start	20.0~~ng~~ug/km	-	7

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Gasoline-catalyst vehicle, FTP test, cold start.	0.2~~ng~~ug/km	-	7
		Gasoline, 15% methanol FTP test, cold start	6.4ng/km	-	7
		Diesel vehicle, FTP test, cold start	263~~ng~~ug/km	-	7
		Ferroalloy plants	-	-	15
		Coal liquefaction pilot plant, USA	-	-	15
		Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		1978 Oldsmobile diesel engine particulates extract.	Identified	-	33
		Extract of soot collected from flames, benzene + air mixture fuel, % extract fraction range in 40^{o}c to 200^{o}c. (Pyrene and Benzoacenaphthylene)	99-33	-	31
		Ferroyalloy furnaces			
		Open silicon metal furnace, gas phase.	37~~ng~~ug/m^3		108
		emission.	24gms/hr		
		Covered ferrosilicon furnace, secondary fumes,			
		gas phase (approximate)	9~~ng~~ug/m^3		
		emissions (approximate)	6gms/hr		
		Foundries, Ontario			109
		Personal samples, maximum	12.93~~ng~~ug/m^3		
		Area samples, maximum	23.21 ug/m^3 ~~23/21ng/m^3~~		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Residential wood stove~~s~~ (~~ng~~ µg/kg dry fuel burned)		—	126
		Birch: Normal combustion	2690		
		Birch: Starved combustion	1488		
		Spruce: Normal combustion	232		
		Spruce: Starved combustion	3822		
		Residential charcoal stove (~~ng~~ µg/kg dry fuel burned) to be reduced by a factor of 3 to 4 for comparison with wood.	20.1		
		In carbon paper (~~ng~~ µg/sheet)	35.7		113
		Coal fly ash, tentative	Identified		
		Coal fly ash extract, as % of extract.	0.46 ± 0.02		121
		Pilot plant coal gasification gas: subbituminous coal, lignite coal (or fluoranthene)	Identified	-	128
		Pilot plant coal gasification, base-neutral water extract of raw gas.		-	128
		Subbituminous coal	5.3mg/l		
		Lignite coal	2.5mg/l		
		1978-1980 diesel cars exhaust particulates	18.6-105ng/mg particulates	-	71
		Airtight woodburning stoves, seasoned oak, two sizes, two burn rates, as pyrenes.	0.33 and 1.39mg/kg wood	-	73
		Baffled stove, seasoned oak, as pyrenes	15.6mg/kg wood		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Airtight wood burning stove, seasoned oak, two sizes, two burn rates, polar fraction condensable fraction of stack gases.	0.0174, 0.2850 and 1.3947 mg/kg wood	-	73
		In creosote	0.0261mg/kg wood		
		Wood combustion: as % of total PAHs		-	74
		Furnace with pre-chambers woodchips	<7.5%, 9.43%		
		Fireplace, woodchips	7.59% 10.0%		
		Furnace, wood	13.13% 8.46% and 7.78%		
		Modified fireplace, wood	12.2% 11.46% 11.02% and 13.13%		
		Airtight stove wood	9.62%, 9.8% 10%, 10.95%, 10.79%		
		Wood stove, varying burn modes, - side draft, up draft, down draft, high turbulence draft. Total wood burned 6.33 go 6.79kg.		-	129
		Seasoned oak (low-high)			
		Particulates	0.07-2.8mg		
		Gaseous	6.8-38mg		
		Green pine			
		Particulates	3.1mg		
		Gaseous	6.1mg		
		Wood stove with a catalytic combustor, condensable fraction.		-	75
		Before the combustor	85ug/of organics		
		After the combustor	47ug/of organics		
		As C_1-Fluoranthene/pyrene			
		Before the combustor	11ug/of organics		
		After the combustor	2ug/of organics		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Triphenylene	217-59-4	Gasifier using wastes such as residential garbage and agricultural wastes.	-	-	15
		1978 Oldsmobile diesel engine particulates extract.	Identified	-	33
		Wood stoves burning wood including oak, maple and pine, Canada (as chrysene and triphenylene)	2-139 ug ~~mg~~/kg fuel	-	55
		Wood burning furnace emissions, Canada. (as chrysene and triphenylene)	trace 4.7 ~~mg~~ ug/gm particulates	-	~~53~~ 55
		Pilot plant coal gasification gas: water soluble components, subbituminous coal and lignite coal.	Identifi~~cation~~ed	-	128
		Pilot plant coal gasification, base-neutral water extract of raw gas, as chrysene/triphenylene		-	128
		Subbituminous coal	3.6mg/1		
		Lignite coal	1.4mg/1		
		Residential wood stove (~~mg~~ ug/kg dry fuel burned) (as chrysene and triphenylene)			
		Birch: normal combustion	615		
		Birch: starved combustion	481		
		Spruce: normal combustion	not available		
		Spruce: starved combustion	829		
		Residential charcoal stove to be reduced by a factor of 3 to 4 (~~mg~~ ug/kg dry fuel burned) for comparison with wood.	~~15~~ 1.6		

EMISSIONS

PAH	CAS NUMBER	SOURCE/LOCATION	EMISSION CONCENTRATION	YEAR	REF.
Triphenylene	217-59-4	Coal fly ash, tentative	identified	-	121

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Ace~~r~~napnthene	83-32-9	Urban Air	Detected	-	137
		Urban Air	0.01-0.76 ~~ng~~ ug/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	Berkenes; Norway	0.003-0.23ng/m^3		13
		Rorvik; Sweden	0.01-018ng/m^3		13
		Essen; West Germany	0.5-3.75 ng/m^3	Oct 1978 - Sept 1979	12
		A city in West Germany representative of the following areas.		Oct 1978 Sept 1979	12
		Coal heating area	3.125ng/m^3		
		Oil heating area	1.5ng/m^3		
		Automobile traffic area	10ng/m^3		
		Coke plant area	9.4ng/m^3		
		Snow, rain and ice samples, Norway	detected	-	~~37~~ 3
		Air samples, Southern Norway	detected	-	~~37~~ 3
		Riso, Copenhagen	0.05 ± 0.02ng/m^3	Feb-April 1982	48
		Lake Michigan, USA	0.56ng/m^3	1975 - 1977	63
		A city in Germany, Residential coal heating as primary source.	6ng/m^3	-	64
		A city in Germany, Residential coal heating area, relative concentration range with benzo(e) Pynene = 1.0	0.07 -0.3	Jan - April 1979	64
		A city in Germany, automotive traffic area at a tunnel, relative concentration range with benzo(e) pynen = 1.0	0.125 -1.7	Jan - April 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Anthracene	120-12-7	A city in Germany concentration relative to benzo(e) pynene = 1.0		-	64
		Coal heating area	0.0625		
		Oil heating area	0.23		
		Coke ovens area	0.44		
		Automobile traffic area	0.06		
		New Hampshire USA		1979-1980 Cold Season	77
		Lyme Center: Mean	$0.04 ng/m^3$		
		Range	$0.0-0.06 ng/m^3$		
		Urban Hanover			
		: Mean	0.09 ng/m^3		
		Range	$0-0.26 ng/m^3$		
		Moose Mountain			
		: Mean	$0.02 ng/m^3$		
		Range	$0.02-0.02 ng/m^3$		
		Bingham Hill - Vermont			
		: Mean	$0.02 ng/m^3$		
		Range	$0.01-0.04 ng/m^3$		
		Urban Air	0.48-645.65 ~~ng~~ ug$/1000 m^3$	-	96
			1-7.59 ~~ng~~ ug/ $1000 m^3$	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Anthracene -9,10-dione	84-65-1	Ruhr	Identified	Feb-April 1982	54

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benz(a) Anthracene	56-55-3	Berkenes, Norway	0.10-1.86ng/m^3		13
		Rørvik, Sweden	0.12-1.36ng/m^3		13
		Essen, West Germany	1.25-12.5ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany, coal heating area	31.25ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany Oil heating area	9.5ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany Automobile traffic area	50ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany Coke plant area	75ng/m^3	Oct 1978-Sept 1979	12
		Suspended particulate extracts, 50 cities in West Germany, chryfene = 100	20	-	3
		Snow, rain and ice samples Norway	detected	-	~~39~~ 3
		Riso, Copenhagen	0.4 ± 0.2ng/m^3	Feb-Apr 1982	48
		Los Angeles	0.06ng/m^3	-	47
		Tokyo	7.8ng/m^3	-	47
		Newark, New Jersey, USA (filter particulates extracts)	0.7ng/m^3	Nov 1979	62
		Lake Michigan, USA	0.94ng/m^3	1975-1977	63
		City in Germany Residential Coal heating as primary source	100-148ng/m^3	-	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benz(a) Anthracene	56-55-3	A city in Germany with residential coal heating. Relative concentration range, with benzo(e) pyrene = 1.0	1.25-1.625	Jan - April 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range, benzo(e) pyrene = 1.0	0.75-1.25	Jan - April 1979	64
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Oil heating area	1.0		
		Coal heating area	1.38		
		Coke ovens area	1.125		
		Automobile traffic area	1.13		
		New Hampshire, USA (Wood combustion sources)		1979-1980 Cold season	77
		Lyme Center, Mean	0.43 ng/m^3		
		Range	0.14ng-1.43ng/m^3		
		Urban Hanover			
		Mean	1.50ng/m^3		
		Range	0.26-2.76ng/m^3		
		Moose Mountain			
		Mean	0.33ng/m^3		
		Range	0.24-0.39ng/m^3		
		Brigham Hill, Vermont			
		Mean	0.25ng/m^3		
		Range	0.05-0.51ng/m^3		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benz(a) Anthracene	56-55-3	Gotenborg low-high range	1.1-5.2ng/m^3	Feb 25-26 - March 27-28,1980	69
			2.6ng/m^3	April 1980	69
		Birmingham, Alabama, USA	11.1ng/m^3	-	96
		Urban Air	0.03-933.25~~ng~~μg/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benz(a) Anthracene -7,12 dione	2498-66-0	Ruhr	Identified	Feb-Apr 1982	54

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) Acridine	225-11-6	Urban Air As Benzacridine	1.32-ug/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(c) Acridine	225-51-4	Airborne particulates, USA	0-15~~ng~~µg/1000m^3	1966	137
		Average American urban atmosphere, benzene soluble fraction	50~~mg~~µg/g	-	137
		airborne particulates	4~~ng~~µg/g; 0.6~~ng~~µg/1000m^3 in air	-	137
		Atmospheric particulates, tobacco smoke, synthetic fuel wastes, coke oven effluents	Identified	-	137
		Atmosphere of 2 cities in North Rhine, West Phalia, West Germany Ratio of benz(c) Acridine to benzo(a) pyrene, coal processing and combustion as main ~~service~~ source.	 0.1-0.3 Greater than in cities in USA	-	137
		Urban Air as Benzacridine	1.32 - ~~ng~~µg/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(b) Fluoranthene	205-99-2	Berkenes, Norway	0.08-5.85ng/m^3		13
		Rørvik, Sweden	0.37-2.57 ng/m^3		13
		Essen, West Germany	3-16.25ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representing each of the following areas:			
		Coal heating area	31.25ng/m^3		
		Oil heating area	15ng/m^3		
		Automobile traffic area	40.625ng/m^3		
		Coke plant area	62.5ng/m^3		
		Suspended particulate matter extracts, 50 cities in West Germany, chrysene = 100, as benzo (band j) fluoranthenes	5	-	3
		Air samples, Southern Norway	deleted	-	~~31~~ 3
		Riso, Copenhagen as benzo (b, j and K) fluoranthenes	1.3 ± 0.5ng/m^3	Feb-Apr 1982	48
		Toronto, Canada as benzo fluoranthenes	0.12ng/m^3	-	47
		Antwerp, Belgium as benzo fluoranthenes	25.1ng/m^3	-	47
		Unknown location ratio of particle to vapor phase concentrations as benzo flouranthenes	0.19-11.5	-	47
		A city in Germany, residential coal heating, relative concentration range in the benzo(e) pyrene = 1.0	1.0-1.4	Jan-Apr 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(b) Fluoranthene	205-99-2	A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	0.94-1.375	Jan-Apr 1979	64
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	1.35		
		Oil heating area	1.625		
		Coke ovens area	1.18		
		Automobile traffic area	1.20		
		Götenborg low-high range as benzo(b,j,k) fluoranthenes	1.6-7.8ng/m^3	Feb 25-26 - Mar 27-28, 1980	69
			3.8ng/m^3	Apr 1980	69
		Urban Air	0.09-4.84~~mg~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo~~(y)~~ (j) fluoranthene	205-82-3	City in Germany, Residential coal heating as primary source, as benzo(j and k) fluoranthenes	123-124ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration on range with benzo(e) pyrene = 1.0 and as benzo(j and k) fluoranthenes	0.8-1.2	Jan-Apr 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0, as benzo(j) and k) fluoranthenes	0.875-0.99	Jan-Apr 1979	64
		A city in Germany, concentrations as benzo(j and k) fluoranthenes relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	1.185		
		Oil heating area	1.45		
		Coke oven area	1.0		
		Automobile traffic area	1.0		
		Dust from air, Detroit	0.62mg/kg	-	137
		Götenborg, low-high range	1.6-7.8ng/m^3	Feb 25-26 - Mar 27 -28, 1980	69
		As benzo(b,j,k) fluoranthenes	3.8ng/m^3	Apr 1980	

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo (~~g~~)(j) fluoranthene	205-82-3	Essen, West Germany as Benzo (~~g~~ j and K) fluoranthenes	$2.5\text{-}12.5 ng/m^3$	Oct 1978-Sept 1979	12
		A city in West Germany representing each of the following areas (as benzo ~~g~~ j and k fluoranthenes)			
		Coal heating area	$28 ng/m^3$		
		Oil heating area	$15.5 ng/m^3$		
		Automobile traffic area	$62.5 ng/m^3$		
		Coke plant area	$54.6 ng/m^3$		
		Suspended particulate matter extracts, 50 cities in West Germany, chrysene = 100, as benzo (b and j ~~g~~) fluoranthenes	5		3
		Air samples, Southern Norway, as benzo (~~g~~ j and k) fluoranthenes	detected	-	~~37~~ 3
		Riso, Copenhagen as benzo (b, ~~g~~ j and k) fluoranthenes	$1.3 \pm 0.5 ng/m^3$	Feb-Apr 1982	48
		Toronto, Canada as benzo fluoranthenes	$0.12 ng/m^3$	-	47
		Antwerp, Belgium as benzo fluoranthenes	$25.1 ng/m^3$	-	47
		Unknown location, ratio of particle to vapor phase concentrations as benzo fluoranthenes	0.19-11.5	-	47
		Rutherford, New Jersey, USA	Identified	Sept 1979	62
		Urban Air	0.01-0.65 ~~gn~~ ug/$1000m^3$	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(k) fluoranthene	207-08-9	Berkenes, Norway	0.07-3.99ng/m^3		13
		Rørvik, Sweden	0.16-0.74ng/m^3		13
		Essen, West Germany as Benzo (j and k) fluoranthenes	2.5-12.5ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representing each of the following areas (as benzo j and k fluoranthenes		Oct 1978-Sept 1979	12
		Coal heating area	28ng/m^3		
		Oil heating area	12.5ng/m^3		
		Automobile traffic area	62.5ng/m^3		
		Coke plant area	54.6ng/m^3		
		Suspended particulate matter extracts, 50 cities in West Germany, chrysene ≐ 100	25	-	3
		Air samples, Southern Norway, as benzo (j and k) fluoranthenes	detected	-	~~37~~ 3
		Northern Ontario, Canada. 4 sites at distances as from 0.8km to 2.8 km from a steel mill with one site at 3.5 km from the mill until 1975		1971-1979	31
		Geometric Mean Range	0.39-1.62ng/m^3		
		Maximum Value Range	5.1-142.0ng/m^3		
		Higher concentrations at sites closer to the mill			
		Riso, Copenhagen as benzo (b,j and k) fluoranthenes	1.3 ±0.5ng/m^3	Feb-Apr 1982	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(k) fluoranthene	207-08-9	Northern Ontario, urban residential area, at distances greater than 2km from known industrial sources	0.1 to 0.9ng/m^3 Geometric mean	1971-1979	31
		At distances less than 2km from known industrial sources, geometric mean.	1.0-5ng/m^3		
		Toronto, Canada as benzo fluoranthenes	0.12ng/m^3	-	47
		Antwerp, Belgium as benzo fluoranthenes	25.1ng/m^3	-	47
		Unknown location, ratio of particle to vapour phase concentrations as benzo fluoranthenes	0.19-11.5	-	47
		Neward, New Jersey, USA (filter particulates extracts)	1.3ng/m^3	November 1979	62
		Rutherford, New Jersey USA (filter particulates extracts)	Identified	September 1979	62
		City in Germany, residential coal heating as primary source as benzo(j and k) fluoranthenes	123-124ng/m^3	-	64
		A city in Germany residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0 and as benzo (j and k) fluoranthenes	0.8-1.2	Jan-Apr 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(k) Fluoranthene	207-08-9	A city in Germany, Automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0 as benzo (j and k) fluoranthenes	0.875-0.99	Jan-Apr 1979	64
		A city in Germany, concentrations as benzo(j and k) fluoranthenes relative to benzo(e) pyrene = 1.0		-	64
		Cool heating area	1.185		
		Oil heating area	1.45		
		Coke ovens area	1.0		
		Automobile traffic area	1.0		
		Götenborg low-high range as benzo (b,j,k) fluoranthenes	1.6-78ng/m^3	Feb 25-26 - Mar 27 - 28,1980	69
			3.8ng/m^3	April 1980	69
		Urban Air	0.03 - 17.78 ug/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Berkenes, Norway	0.07-2.35ng/m^3		13
		Rørvik, Sweden	0.07ng/m^3		13
		Essen, West Germany	2.5-20ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representative of each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	15ng/m^3		
		Oil heating area	10ng/m^3		
		Automobile traffic area	54ng/m^3		
		Coke plant area	9.4ng/m^3		
		Suspended particulate matter extracts, 50 cities in West Germany chrysene = 100	20	-	3
		Air samples, Southern Norway	detected	-	3
		Northern Ontario, Canada Three sites at distances from 0.8km to 2.8km from a steel mill.		1971-1979	30
		Geometric Mean Range	0.94-3.45ng/m^3		
		Max. Value Range	8.5-90 ng/m^3		
		Riso, Copenhagen	0.6±0.2ng/m^3	Feb-Apr 1982	48
		Toronto, Canada	0.20ng/m^3	-	47
			10.5ng/m^3	-	47
		Unknown location, ratio of particle to vapour phase concentrations.	∞	-	47
		Newark, New Jersey USA	3.3ng/m^3	November 1979	62
		Rutherford, New Jersey USA	Identified	September 1979	62

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Lake Michigan, USA	1.75ng/m^3	1975-1977	63
		A city in Germany, residential coal heating as primary source	50-60ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.5-0.625	Jan-Apr 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	1.125-2.12	Jan-Apr 1979	64
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.625		
		Oil heating area	0.68		
		Coke ovens area	0.62		
		Automobile traffic area	0.563		
		New Hampshire, USA (wood combustion sources)		1979-1980	77
		Lyme Center, Mean:	0.66ng/m^3		
		Range	0.2-2.06 ng/m^3		
		Urban Hanover:			
		Mean	1.53ng/m^3		
		Range	0.42-0.68ng/m^3		
		Moose Mountain			
		Mean	0.55ng/m^3		
		Range	0.42-0.68ng/m^3		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(ghi) perylene	191-24-2	Brigham Hill, Vermont			
		Mean	0.36ng/m^3		
		Range	0.05-0.58ng/m^3		
		Birmingham, Alabama USA	13.8ng/m^3	-	96
		Urban Air	0.02-177.83 ug /1000m^3	-	96
		Rural Air	2.95-56.23 ug /1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Suspended particulate matter extracts, 50 cities in West Germany, chrysene = 100	15	-	3
		Snow, rain and ice samples, Norway	detected	-	3 ~~37~~
		Precipitation, maximum as benzo(a and e) pyrene, Norway	300mg/liter	-	3 ~~37~~
		Air samples, Southern Norway	detected	-	37
		Northern Ontario, Canada. 4 sites at distances from 0.8km to 2.8km from a steel mill with one site at 3.5km from the mill until 1945 Geometric mean range Maximum Value Range Higher concentrations at sites closer to the mill	 0.21-1.15ng/m^3 7.9-110.0ng/m^3	1971-1979	30
		Northern Ontario, Canada. Urban residential area about 2km from known industrial sources Geometric mean range Geometric mean range At distances less than 2km from known industrial sources.	 0.1-5ng/m^3 0.6-2.5ng/m^3	1971-1979	30
		Detroit, USA	0.8-1.5ng/m^3	-	48
		Honolulu	0.01ng/m^3	-	48
		Essen, West Germany	7.9ng/m^3	-	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Helsinki	0.5-5ng/m^3	-	2
		Berkenes, Norway	0.06-2.35ng/m^3		13
		Rønvik, Sweden	0.11-1.16ng/m^3		13
		Essen, West Germany	1.25-12ng/m^3	Oct 1978-Sept 1979	12
		Ontario, Canada (summer)	0.6-18.5ng/m^3	Oct 1961-1962	12
		Ontario, Canada (winter)	1.5-20ng/m^3	1961-1962	12
		Duisbery, West Germany	5-737ng/m^3	1973-1978	12
		Los Angeles, USA	0.03-3.5ng/m^3	1972	12
		Bombay, India	0.8-3.9ng/m^3	1973	12
		Essen, West Germany	3-297ng/m^3	1978-1979	12
		Budapest, Hungary, (winter)	27ng/m^3	1971-1972	12
		Stockholm, Sweden	0.44-0.86ng/m^3	1981	22
		Oslo, Norway	0.4-17.5ng/m^3	-	22
		Nonurban aerosol	0-0.17~~ng~~μg/mg extractable organic matter	-	25
		Urban continental aerosol	0.15-0.61~~ng~~μg/mg extractable organic matter	-	25
		Maritime urban aerosol	0.21-0.26~~ng~~μg/mg extractable organic matter	-	25

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	A city in West Germany representative of each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	15.6ng/m^3		
		Oil heating area	6.125ng/m^3		
		Automobile traffic area	37.5ng/m^3		
		Coke plant area	50ng/m^3		
		Unknown location ratio of particle to vapor phase concentrations	7.5-∞	-	47
		Newark, New Jersey USA (filter particulates extracts)	1.5ng/m^3	November 1979	62
		Rutherford, New Jersey, USA (filter particulates extracts)	Identified	September 1979	62
		Lake Michigan, USA	1.05ng/m^3	1975-1977	63
		A city in Germany, residential coat heating as primary source	53-75ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.625-0.8	Jan-Apr 1979	64
		A city in Germany, residential coal heating area, low-high concentration range	$\sim$1-$\sim$70ng/m3	Oct 1978-Mar 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	A city in Germany, automobile traffic area, low-high concentration range.	10-104ng/m^3	Oct 1978-Mar 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	0.75-1.3	Jan-Apr 1979	64
		A city in Germany, low-high concentration ranges representing		Oct 1978-Mar 1979	64
		Oil heating area	1-22ng/m^3		
		Coke ovens area	5-208ng/m^3		
		Rural area outside the city	0.5-8.5ng/m^3		
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.53		
		Oil heating area	0.82		
		Coke ovens area	1.225		
		Automobile traffic area	1.0		
		New Hampshire, USA (wood combustion source)			
		Hanover Mean	1.62ng/m^3	1979-1980	77
		Range	0.4-2.97ng/m^3	Cold season	
		Ly~~n~~me Cent~~re~~er Mean	0.48ng/m^3		
		Range	0.18-1.23ng/m^3		
		Hamilton, Ontario Canada (Annual average for 1975/76 and 1977/78)	2.3-3.62ng/m^3	1975/76 1977/78	

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Baltimore, USA	0.32ng/m^3	1977	138
		Detroit, USA	0.42ng/m^3	1977	138
		New York, USA	0.47ng/m^3	1977	138
		Youngstow, USA	1.2ng/m^3	1977	138
		Bethlehem, USA	0.15ng/m^3	1977	138
		Philadelphia, USA	0.45ng/m^3	1977	138
		Chattanooga, USA	0.66ng/m^3	1977	138
		Urban Air	0.01-131.83~~ng~~ug/ 1000m^3 to 1000~~ng~~ug/1000m^3	-	96
		Rural Air	0.003-42.66~~ng~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(a) pyrene	50-32-8	Colorado, quarterly mean range (3rd and 4th quarter)	$0.2-0.96ng/m^3$	-	78
		Tellurido, Colorado, USA	$0.6-3.4ng/m^3$		78
		4 sites representing ground level and elevated locations, low-high ranges	$3.2-14.8ng/m^3$ 0.04-[illegible]$7.4ng/m^3$ Not detectable		
		Urban aerosols, Ontario particle size ≤1.1~~km~~ um particle > 1.1~~km~~ um	1,08~~ng~~ ug per 1000 m^3 ~~0.16ng/1000m~~ 0.16~~ng~~ ug/1000m^3	-	96
		Götenborg low-high range	$0.17-2.4ng/m^3$	Feb 25-26 - Mar 27-28, 1980	69
			$0.51ng/m^3$	Apr 1980	69
		Birmingham, Alabama USA	$17.8ng/m^3$	-	138
		Honolulu, USA	$0105ng/m^3$	1977	138
		Chicago, USA	$0.21ng/m^3$	1977	138
		Montgomery, USA	$0.048ng/m^3$	1977	138
		New Orleans, USA	$0.18ng/m^3$	1977	138

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(e) Pyrene	192-97-2	Essen, West Germany	3-11.25ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany, representative of each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	25ng/m^3		
		Oil heating area	12.5ng/m^3		
		Automobile traffic area	63ng/m^3		
		Coke plant area	65.6ng/m^3		
		Suspended particulate matter extracts, 50 cities in West Germany - chrysene = 100	45	-	3
		Snow, rain and ice samples, Norway	detected	-	31
		Precipitation samples maximum as benzo (a+c) pyrene	300mg/liter	-	31
		Air samples, Southern Norway	detected	-	31
		Riso, Copenhagen	0.6 ± 0.2ng/m^3	Feb-Apr 1982	48
		Toronto, Canada	0.38ng/m^3	-	47
		Washington, USA	4.6ng/m^3	-	47
		Unknown location ratio of particle to vapor phase concentrations	7.5-~~00~~ ∞	-	47
		Rutherford, New Jersey USA (filter particulates extracts)	Identified	Sept 1979	62

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Benzo(e) pyrene	192-97-2	A city in Germany, residential coal heating as primary source.	100ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	1.0	Jan-Apr 1979	64
		A city in Germany, automobile traffic area, at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	1.0	Jan-Apr 1979	64
		A city in Germany, concentrations relative benzo(e) pyrene = 1.0		-	64
		· Coal heating area	1.0		
		Oil heating area	1.0		
		Coke ovens area	1.0		
		Automobile traffic area	1.0		
		New Hampshire, USA (Wood combustion sources)		1979-1980 cold season	77
		Lyne Center, Mean	0.97ng/m^3		
		Range	0.53-2.18ng/m^3		
		Urban Hanover Mean	2.81ng/m^3		
		Range	1.16-5.07ng/m^3		
		Moose Mountain Mean	0.87ng/m^3		
		Range	0.73-1.01ng/m^3		
		Brigham Hill, Vermont			
		Mean	0.52ng/m^3		
		Range	0.15-0.96ng/m^3		
		Birmingham, Alabama USA	13.6ng/m^3	-	96
		Götenborg: low-high range	0.39 – 3.6 ng/m^3	Feb 25-26 March 21-25 1980	69
		Urban Air	0.08-117.49 ~~ng~~ μg/1000m^3	-	96
		Götenborg	1.2 ng/m^3	April 1980	69
		Rural Air	7.59-24.55 ~~ng~~ μg/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Carbazole	86-74-8	Urban Air	1~~ng~~μg/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Berkenes, Norway	0.16-2.35ng/m^3		13
		Rørvik, Sweden	0.39-2.79ng/m^3		13
		Essen, West Germany	5-21.2ng/m^3	Oct 1978-Sept 1979	12
		Snow, rain and ice samples, Norway	detected	-	30
		Air samples, Southern Norway, (as chrysene and triphenylene)	detected	-	31
		A city in Germany, residential coal heating as primary source.	232-256ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	1.75-2.55	Jan-Apr 1979	64
		A city in Germany, Automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	1.395-2.75	Jan-Apr 1979	64
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	2.38		
		Oil heating area	2.50		
		Coke ovens area	1.75		
		Automobile traffic area	1.65		
		New Hampshire, USA (wood combustion sources)		1979-1980	77
		Lyme Center - Mean	0.63ng/m^3		
		Range	0.26-2.07ng/m^3		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Chrysene	218-01-9	Urban Hanover Mean Range	1.80ng/m^3 0.48-2.94ng/m^3		
		Moose Mountain Mean Range	0.61ng/m^3 0.38-0.83ng/m^3		
		Brigham Hill, Vermont Mean Range	0.41ng/m^3 0.1-0.65ng/m^3		
		G~~r~~ötenborg, low-high range as chrysene/triphenylene	0.8-4.0ng/m^3	Feb 25-26 - Mar 22, 28, 1980	69
			2.3ng/m^3	Apr 1980	69
		Urban Air	242.66 ug 0.04-~~242,66n~~g/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Coronene	82-02-0	Essen, West Germany	0.3-3.0ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representative of each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	3.125ng/m^3		
		Oil heating area	3.0ng/m^3		
		Automobile traffic area	3.125ng/m^3		
		Coke plant area	9.4ng/m^3		
		Riso, Copenhagen	0.24 ± 0.06ng/m^3	Feb - Apr 1982	48
		Toronto, Canada	0.08ng/m^3	-	47
		Los Angeles, USA	4.8ng/m^3	-	47
		Newark, New Jersey USA	1.2ng/m^3	November 1979	62
		Rutherford, New Jersey, USA	Identified	September 1979	62
		A city in Germany, residential coal heating as primary source.	12.5-13.5ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.12-0.135	Jan-Apr 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	0.8-1.925	Jan-Apr 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Coronene	82-02-0	A city in Germany, concentration relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.125		
		Oil heating area	0.25		
		Coke ovens area	0.81		
		Automobile traffic area	0.0625		
		Birmingham, Alabama USA	3.2ng/m^3	-	96
		Urban Air	0.15-56.23~~ng~~ug/ 1000m^3	-	96
		Rural Air	2.04-7.5~~ng~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Cyclopenta (cd)pyrene	27208-37-3	Essen, West Germany	1.2-4ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representing each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	3.125ng/m^3		
		Oil heating area	1.5ng/m^3		
		Automobile traffic area	162ng/m^3		
		Coke plant area	25ng/m^3		
		Riso, Copenhagen	0.2 ± 0.1ng/m^3	Feb-Apr 1982	48
		Newark, New Jersey USA	0.5ng/m^3	November 1979	62
		Rutherford, New Jersey, USA	Identified	September 1979	62
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.05-0.13	Jan-Apr 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range benzo(e) pyrene = 1.0	0.7-3.06	Jan-Apr 1979	64
		A city in Germany concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.02		
		Oil heating area	0.375		
		Coke ovens area	3.0		
		Automobile traffic area	0.38		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Dibenz (a,h) acridine	226-36-8-	Average American urban atmosphere benzene soluble fraction. Airborne particulates	7~~mg~~μg/g 0.08~~mg~~μg/1000m^3 air	-	137

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Dibenz (a,j) acridine	224-42-0	Average American urban atmosphere:	~~4mg/g~~	-	137
		benzen soluble fraction	4~~mg~~ug/g		
		Airborne particulates	0.04x 10^{-3} ug/m^3 air		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Dibenz(a,h) Anthracene	53-70-3	Berkenes, Norway	0.03-0.52ng/m^3		13
		Rørvik, Sweden	0.05-0.08ng/m^3		13
		Air samples, Southern Norway	detected	-	3?
		Riso, Copenhagen	0.14 ± 0.08ng/m^3	Feb - Apr 1982	48
		New Hampshire, USA (wood combustion sources data suspect)		1979-1980 cold season	77
		Lyne Center: Mean	1.95ng/m^3		
		Range	0.8-6.71ng/m^3		
		Urban Hanover Mean	4.59ng/m^3		
		Range	1.36-7.73ng/m^3		
		Moose Mountain			
		Mean	1.71ng/m^3		
		Range	1.4-2.01ng/m^3		
		Brigham Hill, Vermont			
		Mean	1.28ng/m^3		
		Range	0.83-1.82ng/m^3		
		Urban Air	0.0032-.032~~ng~~ µg/m^3		136

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Berkenes, Norway	0.17-6.28ng/m^3		13
		Rørvik, Sweden	0.42-3.21ng/m^3		13
		Suspended particulate matter extracts, 50 cities in West Germany, Chrysene = 100	92	-	3
		Snow, rain and ice samples, Norway	detected	-	31
		Air samples, Southern Norway	detected	-	31
		Northern Ontario Canada, Three sites at distances from 0.8km to 2.8km from a steel mill		1971-1979	31
		Geometric Mean Range	0.75-3.06ng/m^3		
		Maximum Value Range	4.8-43.3ng/m^3		
		Los Angeles, USA	0.15ng/m^3	-	47
		Karisrnhe	27.0ng/m^3	-	47
		Unknown location, ratio of particle to vapor phase concentrations	0.07-0.26	-	47
		Lake Michigan, USA	1.03ng/m^3	1975-1977	63
		New Hampshire, USA (wood combustion sources)		1979-1980 cold season	77
		Lyme Center, Mean Range	0.53ng/m^3 0.00-2.61ng/m^3		
		Urban Hanover Mean Range	2.59ng/m^3 0.43-6.93ng/m^3		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Fluoranthene	206-44-0	Moose Mountain Mean	0.41ng/m^3		
		Range	0.28-0.56ng/m^3		
		Brigham Hill, Vermont Mean	0.51ng/m^3		
		Range	0.2-1.04ng/m^3		
		Götenborg low-high range	0.64-3.4ng/m^3	Feb 25-26 -Mar 27-28 1980	69
			1.7 ng/m^3	April, 1980	
		Birmingham, Alabama USA	7.4ng/m^3	-	96
		Urban Air	0.13-75.86~~ng~~ug/ 1000m^3	-	96
		Rural Air	4.22-23.44~~ng~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Fluorene	86-73-7	Lake Michigan, USA	1.08ng/m^3	1975- 1977	63

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
9-Fluorenone	486-25-9	Ruhr as Fluorenone	Identified	Feb-Apr 1982	54

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Indeno (1,2, 3,-cd) pyrene	193-39-5	Essen, West Germany	1.25-13ng/m^3	Oct 1978-Sept 1979	12
		Suspended particulate matter, 50 cities in West Germany, chrysene = 100	22	-	3
		Riso, Copenhagen	0.7 ± 0.2 ng/m^3	Feb-Apr 1982	48
		A city in Germany, residential coal heating as primary source.	56-56.5ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.44-0.625	Jan-Apr 1979	64
		A city in Germany, automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	0.7-1.06	Jan-Apr 1979	64
		A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.5625		
		Oil heating area	0.935		
		Coke ovens area	0.70		
		Automobile traffic area	0.563		
		Dust from air samples, Detroit, USA	0.96mg/kg	-	137
		Urban Air	0.75-2.37~~ng~~ug/1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Naphthalene	091-20-3	Urban Air	0.01-~~0.31ng~~ 0.41 μg/ 1000m^3	-	96
		Rural Air	0.05-0.06~~ng~~ μg/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Naphthacene-5,12-dione	1090-13-7	Ruhr	identified	Feb-Apr 1982	~~84~~ 54

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
9-Nitro anthracene	602-60-8	Riso, Copenhagen	0.03 ± 0.01ng/m^3	Feb-Apr 1982	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
6-Nitro benzo(a) Pyrene	63041-90-7	Riso, Copenhagen	Identified	-	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
8-Nitro fluoranthene	13177-32-7	Riso, Copenhagen	Identified	-	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
1-Nitropyrene	5522-43-0	Riso, Copenhagen	0.009 ± 0.00[illegible]5 ng/m^3	Feb-Apr 1982	48
		Detroit, Michigan	0.016-0.030ng/m^3	-	48

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
PAH		Northern Bavaria, West Germany	detected	-	30
		Barrow, Alaska	detected	-	31
		Particulates - methylene chloride extracts (%)	0.105-0.48	-	72
		Urban Air, Dearborne Michigan, USA			
		Highway Air, Allegheny tunnel, Pennsylvania, USA	0.14-0.28	-	
		Rural air near the Allegheny tunnel, Pennsylvania, USA	0.03-0.06		
		Diesel exhaust	0.62-0.79		
		Polycyclic Organic Matter			
		Ambient remote area	$\leq$0.2ng/m^3 ~~50.2ng/m^3~~	-	96
		Urban	10 to 100 times 0.2ng/m^3	-	

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Perylene	198-55-0	Berkenes, Norway	0.02-0.49ng/m^3		13
		Rørvik, Sweden	0.08-0.82ng/m^3		13
		Essen, West Germany	0.5-2ng/m^3	Oct 1978-Sept 1979	12
		A city in West Germany representative of each of the following areas:		Oct 1978-Sept 1979	12
		Coal heating area	3.125ng/m^3		
		Oil heating area	1.5ng/m^3		
		Automobile traffic area	7.5ng/m^3		
		Coke plant area	12ng/m^3		
		Northern Ontario, Canada, Three sites at distances from 0.8km to 2.8 km from a steel mill		1971-1979	30
		Geometric Mean Range	0.22-1.53ng/m^3		
		Maximum Value Range	9.1-106ng/m^3		
		Lake Michigan, USA	0.63ng/m^3	1975-1977	63
		A city in Germany, residential coal heating as primary source	3-5ng/m^3	-	64
		A city in Germany, residential coal heating area, relative concentration range with benzo(e) pyrene = 1.0	0.06-0.2	Jan-Apr 1979	64
		A city in Germany, Automobile traffic area at a tunnel, relative concentration range with benzo(e) pyrene = 1.0	0.0625-0.29	Jan-Apr 1979	64

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Perylene	198-55-0	A city in Germany, concentrations relative to benzo(e) pyrene = 1.0		-	64
		Coal heating area	0.0625		
		Oil heating area	0.25		
		Coke ovens area	0.185		
		Automobile traffic area	0.25		
		Urban Air	0.01-43.15~~ng~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION		AMBIENT CONCENTRATION	YEAR	REF.
Phenanthrene	85-01-8	Berkenes, Norway		0.51-5.09ng/m^3		13
		Rørvik, Sweden		0.22-1.49ng/m^3		13
		Suspended particulate matter extracts, 50 cities in West Germany, Chrysene = 100		25	-	3
		Snow, rain and ice samples, Norway		detected	-	30
		Air samples, Southern Norway		detected	-	31
		Lake Michigan, USA		0.58ng/m^3	1975-1977	63
		New Hampshire, USA (wood combustion source)			1979-1980 cool season	77
		Lyme Center	Mean	0.05ng/m^3		
			Range	0.01-0.9ng/m^3		
		Urban Hanover	Mean	0.6ng/m^3		
			Range	0.04-2.01ng/m^3		
		Moose Mountain	Mean	0.18ng/m^3		
			Range	0.14ng/m^3 - 0.22 ng/m^3		
		Brigham Hill, Vermont				
			Mean	0.13ng/m^3		
			Range	0.04-0.18ng/m^3		
		Götenborg, low-high range		0.42-2.2ng/m^3	Feb 25-26 - Mar 27-28 1980	69
				1.5ng/m^3	April 1980	
		Urban Air		0.32-2692~~ng~~ µg/ 1000m^3	-	96
		Rural Air		0.01-0.05~~ng~~ µg/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Berkenes, Norway	0.12-4.89ng/m^3		13
		Rørvik, Sweden	0.21.2.15ng/m^3		13
		Suspended particulate matter extracts, 50 cities in West Germany Chrysene = 100	60	-	3
		Snow, rain and ice samples, Norway	detected	-	38
		Air samples, Southern Norway	detected	-	39
		Riso, Copenhagen	1.3 ± 0.8ng/m^3	Feb-Apr 1982	48
		Detroit, USA	0.8-1.5ng/m^3	-	48
		Los Angeles, USA	0.23ng/m^3	-	47
		Tokyo, Japan	29.9ng/m^3	-	47
		Lake Michigan, USA	1.13ng/m^3	1975-1977	63
		New Hampshire, USA (wood combustion sources)		1979-1980 cold season	77
		Lyme Center Mean Range	0.58ng/m^3 0.0-2.7ng/m^3		
		Urban Hanover Mean Range	2.92ng/m^3 0.85-9.77ng/m^3		
		Moose Mountain Mean Range	0.43ng/m^3 0.34-0.51ng/m^3		
		Brigham Hill, Vermont Mean Range	 0.82ng/m^3 0.29-1.66ng/m^3		

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Pyrene	129-00-0	Gӧtenborg low-high range	0-64-3.4ng/m^3	Feb 25-26 - Mar 27-28, 1980	69
			2.1 ~~1[illegible]~~ng/m^3	Apr 1980	69
		Birmingham, Alabama USA	6.8ng/m^3	-	96
		Urban Air	0.01-7499~~ng~~ug/ 1000m^3	-	96
		Rural Air	1.91-19.95~~ng~~ug/ 1000m^3	-	96

AMBIENT CONCENTRATIONS

PAH	CAS NUMBER	LOCATION	AMBIENT CONCENTRATION	YEAR	REF.
Triphenylene	211-59-4	Lake Michigan, USA	0.27ng/m^3	1975-1977	63
		New Hampshire, USA (wood combustion sources)		1979-1980 cold season	77
		Lyme Center Mean	0.11ng/m^3		
		Range	0.06-0.14ng/m^3		
		Urban Hanover Mean	0.56ng/m^3		
		Range	0.16-1.14ng/m^3		
		Moose Mountain Mean	0.17ng/m^3		
		Range	0.12-0.22ng/m^3		
		Brigham Hill, Vermont			
		Mean	0.15ng/m^3		
		Range	0.04-0.27ng/m^3		
		Grotenborg low-high range as chrysene/ triphenylene	0.8-4.0ng/m^3	Feb 25-26 - Mar 27-28, 1980	69
			2.3ng/m^3	Apr 1980	69

ENVIRONMENTAL FATE

Theoretical and empirical studies describing the fate of PAHs under environmental conditions are summarised in this section. Information described under simulated environmental conditions are strictly valid under the conditions of the studies. These studies may closely approximate the actual behaviour of PAHs in the environment. Some studies, which were carried out under conditions other than the desired environmental conditions, are also summarised in this section as they help in understanding the behaviour of the chemicals in the environment.

PAHs may react with, other airborne compounds, and free radicals. These include NOx, SOx, Ozone, oxygen, peroxyacetylnitrate, hydroxyl and hydroperoxyl radicals. Mono and dinitro PAHs have been detected in airborne particulates,diesel exhausts and carbon black. (5) Mononitro PAHs can form by hydrogen abstraction from PAHs and subsequent reaction of the aryl radical with NO_2. PAHs adsorbed particulates may react with airborne gaseous NO_2; NO_2 adsorbed on particulates; or NO_2 dissolved in adsorbed water. Adsorption of the NO_2 on particulates is dependent on humidity. The following is a reactivity classification which has been proposed for selected PAHs (5). It is bassed on decomposition rates of selected PAHs in acidic medium in presence ~~pressure~~ of small amounts of nitrate, nitrous acid and dinitrogen tetroxidie. The reactivity decreases with increasing class number. Only PAHs of interest in this project are indicated.

Class	PAHs
I	Dibenz (a,i) anthracene/(Benzo(a)tetracene)
II	Anthracene; Benzo(a)pyrene; Perylene
III	Benzo(a)anthracene; Benzo(ghi)perylene; cyclopenteno(c,d) pyrene; Pyrene
IV	Benzo(e)pyrene; Chrysene; Coronene; Dibenzanthracenes (other than Benzo (a)tetracene)
V	Benzofluoranthenes; Fluoranthene; Indeno (1,2,3-Cd) pyrene; Naphthalene; Phenamthrene; Triphenylene.

Electron donating substituents on the aromatic ring enhance the reactivity of the PAH. These are hydroxyl, alkoxy and akyl substituents. Reactivity is decreased by electrons attracting substituents, examples of which are; ammonium ~~anamonium~~, carboxy, formyl, sulfo, keto and nitro substituents (5).

Presence of a heteroatom in heteroatomic compounds having two or more ring systems is likely to lower the reactivity of the compound. Azaarenes are expected to be less reactive than corresponding PAHs in undergoing nitration reactions. This is based on acid catylsed nitration of aromatic compounds. Azaarenes are weak bases. Protonation of these bases on particles which are acidic, is **expected** to lower the reactivity of these compounds on comparison with corresponding PAHs.

PAHs adsorbed on coal fly ash have been found to undergo photodegradation. 1 and 3-nitrobenzopyrenes have been found to be stable to photodegradation. 6-nitrobenzo(a)pyrene and 9-nitroanthracene have been observed to undergo photodegradation. A probable photodegradation reaction that is suggested is rearrangement of the nitro PAH to nitrite PAH followed by elimination of nitrogen monoxide to form phenoxy radical. These phenoxy radicals then react with nitrogen monoxide and hydrogen radical to form nitrohydroxy compounds or may be oxidised to quinones. The nitrite PAH formed may undergo hydrolysis to hydroxy compound and nitrous acid (5). Electrophilic aromatic reactions and reactions with hydroxyl radicals as bases, reactions of nitro PAHs are expected to be slow.

PAHs may react under laboratory conditions, with SO_3, SO_2, or ultraviolet light activated SO_2 molecules (SO_2^*). Reaction with SO_2^* may result in the formation sulfonic acids. Reactions with SO_3, SO_2 or SO_2^* may result in the formation of sulfones and sulfoxides. Sulfinic acids and sulfoxides may be oxidised to form diaryldi sulfoxides and disulfones. Sulfonic acids are formed in presence of catalysts.

Pyrene reacts with concentrated sulphuric acid at room temperature under laboratory conditions forming a mixture of disulfonic acids.

Benzo(a)pyrene adsorbed on soot particles has been found to react 50% in 50-80 ppm SO_2 concentration. No reaction was observed at 8-10 ppm of SO_2. In presence of light, 50% degradation occurred at both levels of SO_2 concentrations. Reaction products are not known.

Anthracene-9-sulfonic acid formation is observed when anthracene and SO_2 are photolysed catalytically in various solvents at 25^{o}c. 5-40% SO_2 is required at high concentrations of anthracene. Pyrene and benzo(a) pyrene adsorbed on coal fly ash and alumina ~~is~~ reacted with 10% SO_2 in air forming many sulfur containing compounds. These included pyrene-1-sulfonic acid, pyrene disulfonic acid and benzo(a)pyrene sulfonic acid.. Ben~~k~~zo(a)pyrene on glass fiber filter was found to be reactive when exposed to 1 ppm SO_2 in air under 'typical' ambient conditions. Coal fly ash to which additional PAHs were adsorbed and exposed to 100 ppm SO_2 and SO_3 reacted with SO_3 but not with SO_2. The reaction products are not known..

Reaction of PAH with gaseous molecular oxygen is expected to be slow. benzo(a) pyrene is found to be very reactive with ozone Ben~~k~~zo(a)pyrene adsorbed on pelriplates and exposed to 190 ppb of ozone was found to react with a halflife of 0.6 hours. Reactivity was not affected by irradiation. 50% conversion occurred after 1 hour when benzo(a)pyrene coated on glass fiber filters were exposed to 0.1 to 0.2 ppm ozone in air for period varying from 5 minutes to 4 hours. After 4 hours, 80% of benzo(a)pyrene was converted. Similar results in the dark were observed in a similar experiment. Major products formed with ozone are; dialdehydes, dicarboxylic acids and ~~R~~ketocarboxylic acids. Under experimental conditions, the major skeletal structure of the compound that remains after oxidation is the benzanthrone structure. Some PAHs are resistant to oxidation an example of which is benzo(k) fluoranthene.

Ring opening reactions can occur with ~~OH~~ CH radicals resulting in the formation of hydroxy compounds and quinones. PAHs upon reaction with singlet oxygen may form quinones with an endoperoxide as an intermediate. Benzo(a)pyrene is not expected to form an endoperoxide intermediate.

Photochemical transformations of selected PAHs were observed in a study. Fifteen PAHs were deposited on adsorbents silicagel G, aluminum oxide G, cellulose powder and acetylated cellulose 21%. The compounds were then exposed to ultraviolet radiation and room light. Phenanthrene, chrysene, triphenylene and picene did not react. The remaining 11 PAHs including benzo(a)pyrene were found to be reactive on silicagel G and aluminum oxide G. On less polar adsorbents, the reactivities of the 11 PAHs including fluorescene were similar but slower.

Decreased reactivity of PAHs when adsorbed on soot on comparison in pure form is observed. Hence adsorption on soot resists photooxidation. Benzo(a)pyrene and perylene in smoke and benzo(a)pyrene on soot when irradiated, resulted in decreases of 35-65% and 58% respectively. Formation of PAH radical cation and phenoxy radical subsequently upon reaction with ozone have been suggested.

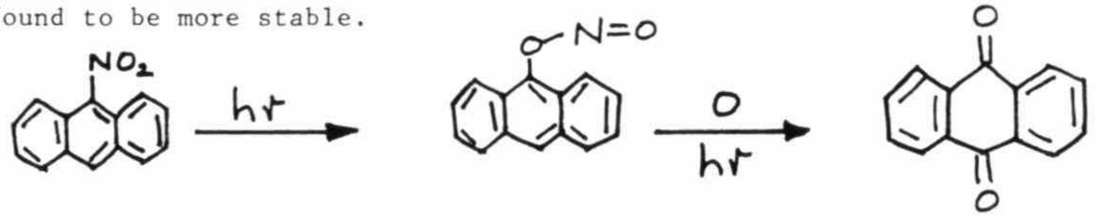
PAHs adsorbed on coal fly ashes from power plants have been found to be resistant to photodegradation. Anthracene adsorbed on atmospheric particulates can be photooxidised to products. In liquid phase, similar oxidation with singlet oxygen is observed.

Photooxidation of PAHs is significant under ambient conditions when compared with ozonation. Preferential adsorptions of PAHs on particles with higher carbon content have been observed, which cause slower reaction rates. Faster rates are observed on aged carbonauous matter than freshly emitted particles. Synergistic effects on rates are observed with some pollutants, examples of which are NO_2 and HNO_3; NO_2 and SO_2.

PAHs adsorbed on glass fiber filters and exposed to NO_2 concentration of 0.25 ppm in air is observed to undergo nitration under laboratory conditions (6). The reaction is catalysed by ~~aid~~ acid such as HNO_2. Benzo~~ear~~(a)pyrene and perylene, when exposed for several hours, react with yields of up to 50% (6). The observed rates of nitration of PAHs with NO_2 were; benzo(a)pyrene and perylene >> pyrene >> chrysene. The relative theoretical rates with chrysene = 1 were: benzo(a)pyrene (6-position nitration) = 31; perylene = 22; pyrene = 4.9.

Benzo(a)pyrene deposited on glass fiber filters and exposed to sub ppm levels of O_3, resulted in oxidation with identification of 1,6-,3,6-; 6,12-benzo(a)pyrene quinones and benzo(a)pyrene - 4,5-oxide as products. This epoxide yield, which is a k-region epoxide, was lower when the filter-coated with ben~~x~~zo(a)pyrene was exposed to actinic light than for ozone exposure in the dark. Benzo(a)pyrene > benzo(a)anthracene > pyrene > fluoranthene >> perylene were the order of reaction for photooxidation and ozonolysis (6). Pyrene upon photooxidation is found to form ~~H~~4-oxa-pyrene-5-one. Phenanthrene on photooxidation is found to form benzoc~~ommari~~oumarin. Oxidation of PAHs at ambient levels of ozone have been observed under simulated and real atmospheric conditions. Quantum yield measurements in a photodegradation study of selected PAHs adsorbed on silicagel and exposed to actinic UV light indicated absolute quantum yield ranges from 8500 x 10^{5} for anthracene to 5.3 x 10^{-5} for benzo(a)pyrene. Tropospheric life time ranges were 0.02 to 10 hours respectively.

Photodegradation and photooxidation, ozonolysis, nitration, of PAHs deposited on filters, occurs mechanisms are not known. The following is a suggestion for photooxidation of 6-nitroanthracene. The 1-and 3-isomers have been found to be more stable.



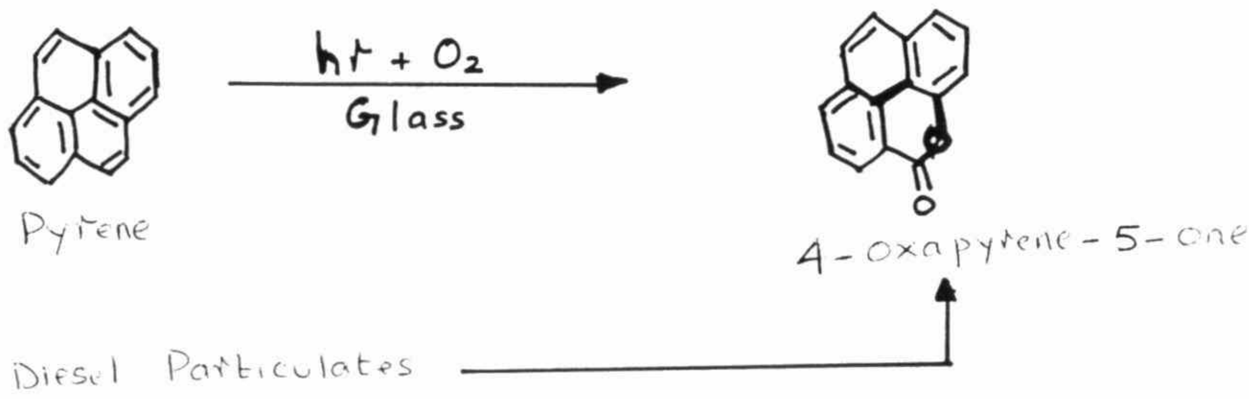
9-Nitroanthracene rearranges to a nitrite; subsequently loses NO to form a phenoxy radical and then forms the anthraquinone.

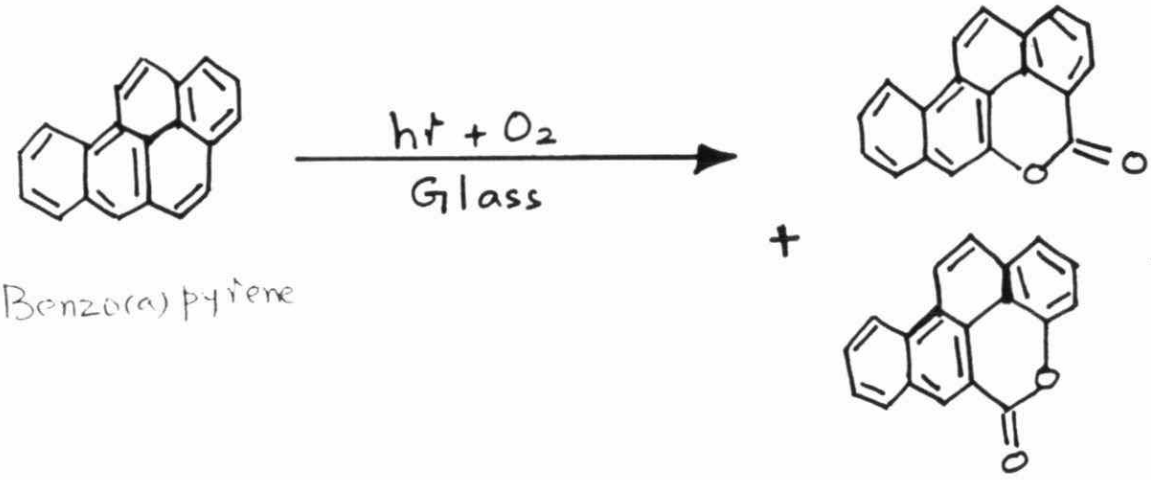
6-Nitrobenzo(a)pyrene is formed as the major product when benzo(a)pyrene is nitrated. 1-and-3-isomers are formed as the minor products, resulting from substitution at electron dense regions. Similar yields are observed on nitration of PAHs on particulate matter and soot. The mechanisms may be different. Urban particulate matter exposed to approximately 1 ppm NO_2 showed similar PAH degradations. These were benzo(a)pyrene to 60%; benz(a)anthracene - 40% and pyrene - 20%.

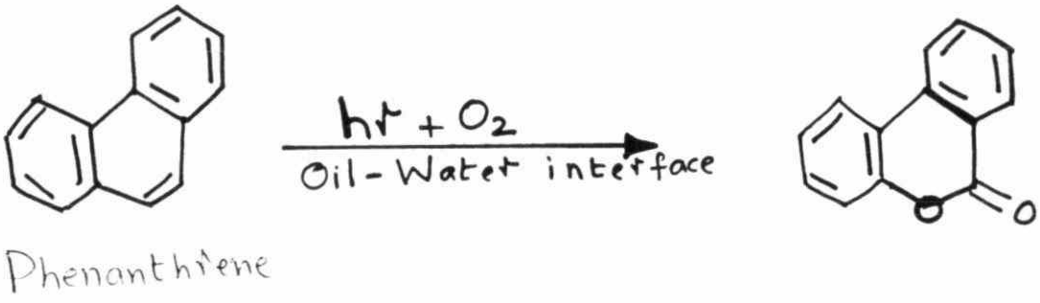
PAHs deposited on lamp black and exposed to sub ppm levels of NO_2 in air in dark; resulted in the formation of 3-Nitro isomer of perylene. One or two other isomers were also formed but were not identified. Identifications of other products and PAHs are not given.

Photodecomposition to quinones is a suggested environmental fate of nitro PAHs. In solution and when adsorbed on silicagel, irradiation of 6-nitroanthracene has been found to form 9,10-anthraquinone. 6-Nitrobenzo(a)pyrene adsorbed on silicagel, photolyses to benzo(a)pyrene quinones (1,6-3,6-and 6,12-isomers) with loss of NO.

The following photooxidised products of selected PAHs are suggested in the reference 6. The products are k-region lactones.







PAHs may act as photosensitizers in the atmosphere. These cause formation of excited oxygen singlet species O_2 ($^1\Delta$). This oxygen species can react with PAHs to form products. Chrysene and 3-methylcholanthrene have been found to undergo such reactions resulting in products which have been found to be direct acting mutagens.(6).

Ozonolysis of benzo(a)pyrene in presence of ozone at concentrations usually found in the atmosphere (0.02 ppm), has been found to form quinones, dialdehydes, dicarboxylic acids, Retocarboxylic acids, dihydroxy derivatives as well as other compounds (8).

In an experiment under laboratory conditions; pyrene and benzo(a)pyrene present on particulates were exposed to varying concentrations of NO_2 and SO_2. Particulates for pyrene study were collected from ethene flame, diesel exhausts and fly ash. Particulates for benzo(a)pyrene study were collected from diesel exhausts and ethene flame. The temperature, NO_2 concentration, SO_2 concentration for five sets of study in the pyrene experiments were respectively; 25°C, 10 ppm, o ppm; 34°C, 3 ppm, 20 ppm; 43°C, 3 ppm, 20 ppm; 25°C, 1.3 ppm, 0 ppm and 300°C, 0 ppm, 0 ppm. The first order rates for loss of pyrene in the study were; 1.5×10^{2} hr^{-1}; 9.9×10^{-2} hr^{-1}; 2.3×10^{-1} hr^{-1}; 6.1×10^{-7} hr^{-1} and 1.2×10^{-7} hr^{-1}. The corresponding nitro PAH formation rates for the second, third and fourth sets of experiments were respectively; 1.1×10^{-2} hr^{-1} ppm^{-1}; 2.1×10^{-2} hr^{-1} ppm^{-1}; 1.1×10^{-1} hr^{-1} ppm^{-1}.

In the benzo(a)pyrene experiments, the temperature, NO_2 concentration and SO_2 concentration for four sets of experiment were respectively 25°C, 10 ppm, 0 ppm; 43°C, 3 ppm, 20 ppm; 300°C, 0 ppm, 0 ppm; 300°C, 0 ppm, 0 ppm. The order rate for loss of benzo(a)pyrene, were successively; 6.4×10^{-2} hr^{-1}; 4.1×10^{-1} hr^{-1}; 3.2×10^{7} hr^{-1}; less than or equal to 8.6×10^{7} hr^{-1}. The observed rate of formation of nitrobenzo(a)pyrene in the second set was 5.7×10^{-2} hr^{-1} ppm^{-1}.

Photolysis of benzo(a)pyrene with light of wave lengths greater than 280nm in the presence of oxygen forms 1,6-; 3,6- and 6,12-benzo(a)pyrene diones (13). PAHs adsorbed on alumina or silicagel undergoes easy oxidation ~~or~~ on exposure to UV light. Oxidation is slower on exposure to visible light or when adsorbed cellulose powder or acetylated cellulose. In an experiment with PAHs, no significant transformation resulted for phenanthrene, chrysene and triphenylene. Anthracene, naphthacene, benz(a)-anthracene, dibenz(a,c) anthracene, dibenz(a,h) anthracene, pyrene, benzo(a)pyrene, benzo(e)pyrene, perylene, benzo(ghi)perylene and coronene reacted significantly (13).

Benzo(a)pyrene adsorbed on particulates is resistant to photooxidation where as benzo(a)pyrene adsorbed on filters readily undergo oxidation.

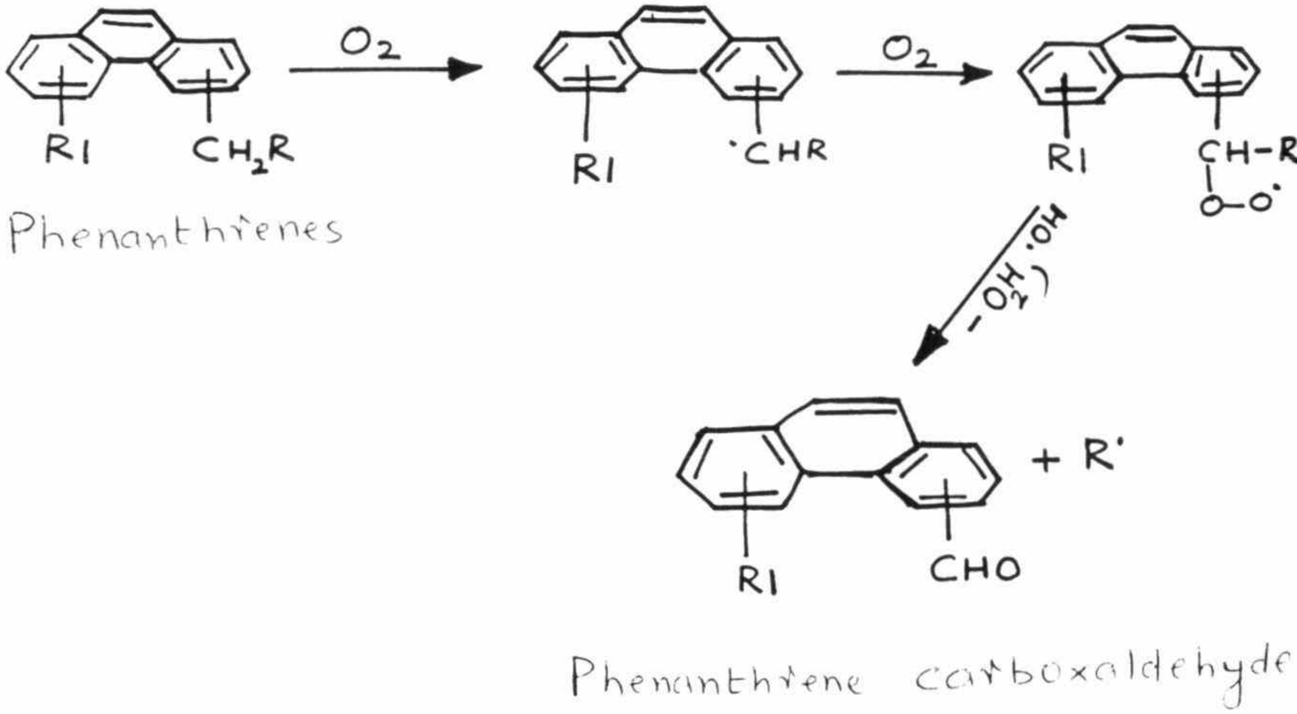
PAHs adsorbed on coal fly ash decompose on exposure to UV light. Pyrene, phenanthrene, fluoranthene, anthracene and benzo(a)pyrene adsorbed on coal fly ~~ahs~~ ash, activated carbon or graphite particles are resistant to photochemical degradation. Decomposition rate of PAHs adsorbed on fly ash when exposed to UV light decreases with increasing number of benzene rings in the PAH. Initial rate is high. The rate decreases subsequently.

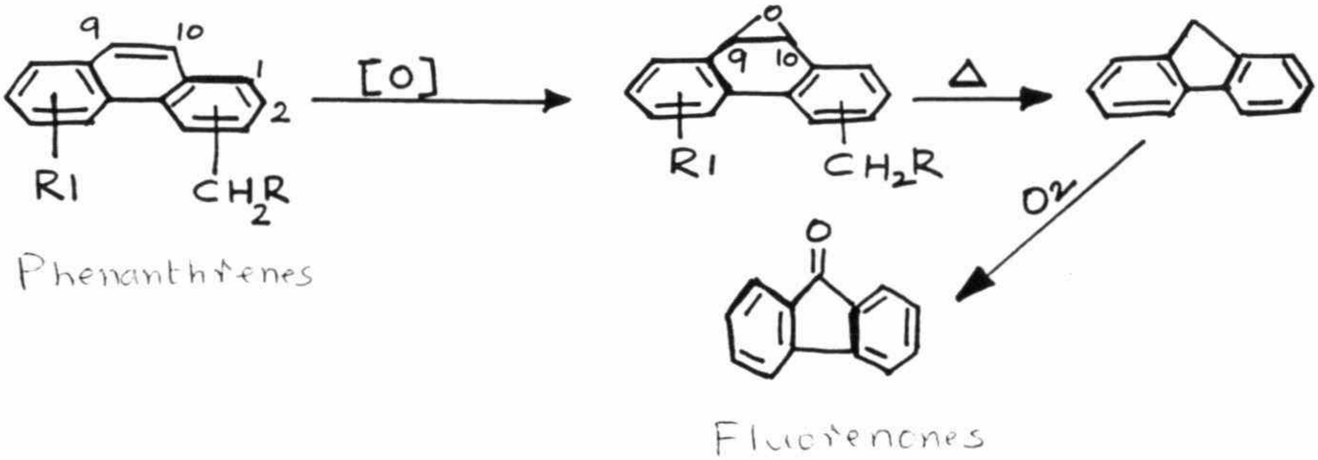
In an experiment with 36.5 nm light, no significant decrease of PAH adsorbed on fly ash with high carbon content was observable after 32 hours of irradiation. Pyrene, phenanthrene, fluoranthene, anthracene and benzo(a)pyrene adsorabed onto coal fly ash, activated carbon or graphite particles results in stabilization of these compounds against photochemical decomposition. Fluorene and aother selected PAHs adsorbed on same types of particles have been found to undergo oxidation in the dark to corresponding quinone or ketone. The following reactivity half lives of selected PAHs in presence and absence of light and ozone are reproduced from reference 13..

PAH	Simulated Sunlight Hrs.	Simulated Sunlight+ Ozone (0.2 ppm) Hrs.	Dark Reaction with Ozone (0.2 ppm) Hrs.
Anthracene	0.20	0.15	1.23
Benzo(a)anthracene	4.20	1.35	2.88
Dibenz(a,h)anthracene	9.60	4.80	2.71
Dibenz(a,c)anthracene	9.20	4.60	3.82
Pyrene	4.20	2.75	15.72
Benzo(a)pyrene	5.30	0.58	0.62
Benzo(e)pyrene	21.10	5.38	7.60
Benzo(b)fluoranthene	8.70	4.20	52.70
Benzo(k)fluroanthene	14.10	3.90	34.70

Presence of PAHs in soot samples in Nova Scotia is considered as evidence of long range transport of these compounds resulting from natural sources and forest fires. PAHs have been detected in rain and snow samples in Norway. The compounds identified included, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(e)pyrene and benzo(a)pyrene.

PAHs and oxygenated PAHs have been detected in extracts of particulates samples collected from a 1978 oldsmobile diesel engine (33). A probable reaction mechanism suggested for the formation of fluorenes and fluroenones involves thermal decomposition of 9,10-epoxy-9,10-dihydrophenathrene or 9-hydroxyphenanthrene. Phenanthrenes may also react to form phenanthrenecarboxaldehydes. The following schemes are suggested in the reference 33.





PAH measurements at sites near a steel mill at Northern Ontario did not show significant variations in concentrations during the cold and warm seasons (30). Cold season measurements were a little higher. The indicated reasons for this increase in concentration levels are; emissions due to residential and commercial heating, lower atmospheric inversion heights during cold seasons and increased decomposition due to increased ambient temperature, oxidant compounds and increasead sunlight.

Strong adsorption is observed for PAHs on coal fly ash (43). PAHs adsorb on carbonaceous material which is not simple physical adsorption. In an adsorption study using fly ash collected from electrostatic precipitator hopper fly ash of a coal fired power plant, modification of fly ash with acid or base did not affect sorption while heat treatment had a significant effect on benzo(a)pyrene sorption. In the study using labelled benzo(a)pyrene, the following adsorption data were obtained.

FLY ASH			ADSORPTION(ng/g)
Untreated electrostatic precipitator hopper collected fly ash.			166
Above indicated fly ash, acid rinsed			143
Above indicated untreated fly ash, basic rinsed			145
Above indicated untreated fly ash subjected to heat treatment;			
	Degree Celcius	- 200	175
		- 300	217
		- 400	256
		- 500	45
		- 600	7
		- 700	12
		- 800	13
Post electrostatic precipitator collected fly ash, subjected to heat treatment;			
	Degree Celcius	- 100	78
		- 300	58
		- 300	231
		- 500	274
		- 600	22

Benzo(a)pyrene adsorption range for no treatment was 166ng/g - 24600ng/g. Heat treatment of fly ash results in initial activation of the site by driving of water is suspected. Adsorption capacity reaches a maximum at about 300 to 500°C above which the surfaces are deactivated and losses of compounds from the surfaces occur. PAHs are formed in hydrocarbon fueled flames (52). Analysis of gases withdrawn from flames have indicated presence of compounds of molecular weight up to 550. In flamed fueled by benzene-oxygen mixture, presence of aromatic radicals, unsaturated aliphatic compounds such as acetylene and hydrogen atoms favour formation of PAHs and soot. Oxidation and pyrolysis reactions of heavy molecular weight species that are likely to be formed in flames such as acetylinic or benzene flames are likely to contribute to formation of PAHs and soot. Unsaturated aliphatic compounds through addition reactions with phenyl radicals or heavy molecular weight species, cause the aromatic structure to grow resulting in the formation of soot. The PAHs that have been detected in flames include; benzo(a)pyrene, fluoranthene, cyclopenta(c,d) pyrene, and cyclopenta(c,d)pyrene epoxide (52).

Soot production is dependent on fuel-oxygen ratio. Variation of effective equivalence ratio which is fuel-oxygen ratio normalized to unity at the stoichiometric value from 1.65 to 1.75 increased soot production by a factor of 50 (52). PAH formation did not increase significantly. In a n-heptane flame, at an equivalance ratio of 2.05, soot formation was of intermediate amount. PAH formation was significant with cyclopenta(c,d)pyrene in particular. Decrease of equivalence ratio ~~as~~ to stoichiometric ratio or more is likely to eliminate the formation of PAHs from nonquenched flames (52).

Nitro derivatives are formed when benzo(a)pyrene and perylene adsorbed on glass fiber filters are exposed to simulated atmospheres containing 1 ppm of nitrogen dioxide and traces of nitric acid. Benzo(a)pyrene deposited on glass fiber filters reacts with ozone at concentration levels found in ambient atmosphere. Some of the products have been found to be direct acting ~~mertegens~~ mutagens in Ames test.

Reactivities of some PAHs that are present in urban aerosols were determined by exposure of urban aerosols to particles free ambient air for days 0, 1, 2 and 4. The following data are from reference 50. Concentrations of fluoranthene and benzo(ghi)perylene did not vary from the initial value of 1236 and 7035 ng/g aged aerosol. Concentrations of perylene, chrysene, benzo(a)pyrene and benz(a)anthracene underwent changes.

CONCENTRATIONS OF PAH (ng/g aged aerosol)

Time (days)	Perylene	Chrysene & Benz(a) anthracene	Benzo(a) pyrene
0	4552	6306	3548
1	4248	5804	2839
2	4058	5276	2286
4	3603	4485	1419
Rate Constant K (days)	0.056	0.085	0.232
Half Life (days)	12.4	8.2	30.

PAHs are present in the atmosphere of diffusion flames and in pyrolysis products of fuel gases (49). In an irradiation study with naphthalene and methylnaphthalene (46), anthracene and fluoranthene were determined as major photo products of naphthalene. 2-methylnaphthalene, biphenyl, 3-methylbiphenyl and pyrene were also detected. With 2-methylnaphthalene, the observed photoproducts were; naphthalene, fluoranthene, benzo(b) fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene and/or indeno (1,2,3-cd) pyrene, benzo(a)anthracene and chrysene. The amounts of photoproducts were increased upon secondary irradiation. The stream which was not subjected to secondary irradiation had fifteen times less of benzo(b)and benzo(k) fluoranthenes and benzo(a) pyrene. Fluoranthene and indeno(1,2,3-cd) pyrenes were eight times less. Chrysene was 0.4 times less and amount of naphthalene remained unchanged. Presence of naphthalene and alkaline hydrocarbons were confirmed by GC/MS.

An experimental liquid phase photolytic ultraviolet and γ-radiation induced oxidation of selected PAHs is described in reference 45. Solid phase photolysis with PAHs adsorbed on Al_2O_3 is also described. The solvents used were benzene and n-octane. $2x10^{-4}M$ solution saturated with oxygen was used. For solid phase photolysis, PAHs dissolved in ethanol or benzene were used. Approximately 22.3~~mg~~ug/g of PAH were used for solid phase photolysis. For aqueous phase, $5x10^{-8}M$ solutions were used depending on solubility. Decomposition rates and half lives (τ) were determined. The data relative to that of benzo(a)pyrene are the following O subscripts refer to benzo(a)pyrene.

Compound	UV		Photolysis in water
	v/vo	v/vo	τ/τ_o
Fluorene	15.23	0.44	7.74
Anthracene	-	1.06	0.52
Phenanthrene	0.32	0.25	4.19
Triphenylene	0.25	0.17	6.06
Pyrene	0.35	0.31	1.29
Chrysene	0.34	0.31	1.67
Benzo(a)anthracene	0.82	0.74	1.35
Benzo(b)anthracene	57.50	19.70	0.23
Dibenzo(a,c) anthracene	0.62	0.56	0.61
Dibenzo(a,h) anthracene	0.62	0.59	0.68
Benzo(a)pyrene	1.00	1.00	1.00
Benzo(e)pyrene	0.29	0.28	1.48
Dibenzo(a,i)pyrene	1.00	1.64	-
Dibenzo(a,h)pyrene	2.48	4.02	-

DECOMPOSITION O$\overset{N}{F}$ Al_2O_3

(Concentration (Mole$\times 10^{-8}$)

Irradiation time (Minutes)	Anthracene	Benzo(a) Anthracene	Benzo(a) pyrene	Chrysene
0	4	4	4	-
5	1.2	2	3	2.85
10	0.8	1.5	2.5	2.35
15	0.6	1.25	2.15	2.00
20	0.55	1.15	1.80	2.00

(Concentration (mole x 10^{-8}

Irradiation (Minutes)	Pyrene and Benzo(e)pyrene	Dibenzo(a,c) anthracene	Benzo(ghi) perylene	Benzo(k) Fluoranthene
0	4	4.0	4	4
5	3.3	3.5	3.05	3.5
10	2.85	3.25	2.70	3.0
15	2.70	3.10	2.50	2.80
20	2.69	3.00	2.49	2.70

Compound	UV v/vo	v/vo	Photolysis in Water τ/τ_o
Perylene	0.66	0.94	24.19
Benzo(ghi)perylene	0.60	0.25	-
Coronene	0.53	0.48	20.13
Fluoranthene	0.17	0.29	-
Benzo(k) fluoranthene	0.20	0.34	7.16
Benzo(b) fluoranthene	0.57	0.75	-

	τ/τ_0	$\tau/\tilde{\tau}_0$	$\tilde{\tau}/\tau_0$
Carbazole	1.24	3.22	-
Benzo(a)acridine	12.0	1.05	4.85
Benzo(c)acridine	0.009	1.16	4.52
Dibenzo(a,h) acridine	-	1.26	-
Dibenzo(a,j) acridine	1.82	1.29	-

Oxidation of PAH occurs through a radical process involving excited triplets. Life times of triplets are expected to be longer than singlets. Presence of nitrogen atom on the PAH ring lowers the reactivity to oxidation.

PAHs are formed in coal-liquified fuel flames (44). Soot and phenanthrene study in the pyrolysis zone of flame fueled by SRC-II heavy distillate fuel indicated slower oxidation of soot compared to phenanthrene oxidation. Under identical conditions, acenaphthene was found to decay less slowly than acenaphthylene. Preferential formation of acenaphthene compared to acenaphthylene from larger molecular weight aromatic compounds and conversion of acenaphthylene to acenaphthene are the suggested reasons for higher concentration of acenaphthene. Naphthalene, alkylated naphthalene and phenanthrene also undergo conversions in the flame environment.

Benzo(a)pyrene and benzo(a)anthracene were found to be photooxidizable in aqueous environment (58). Qinnones and more polar proudcts were identified as the products. Anthracene decomposed slowly. Naphthalene and methylnaphthalene also decomposed in the system.

Treatment of coal fly ash with aqueous bases causes a reduction in mutagenicity which is attributed to hydrolysis of nitro PAH compared to a phenol. Heating of a nitro PAH with an aqueous base results in formation of a phenol. Nitro PAHs are preferentially formed on smaller electrostatic precipitator collected fly ash particles compared to larger particles. Smaller particles are neutral and the larger particles are basic under which nitration of PAH is not likely to occur. Temperature differences between the st~~o~~ack and electrostati~~s~~c precipitator favour formation of PAH by condensation and reactions such as in presence of sulphuric acid. Lower temperature increases the stability of nitro PAHs formed (32).

Irradiation of benzo(a)pyrene in presence of oxygen results in the formation of 1,6-; 3,6- and 6,12- benzo(a)pyrene quinnones (38). Further oxidation to diols and triols and ~~tiny~~ ring fragmented products may also occur. Removal of singlet oxygen during irradiation decreases the rate of photooxidation and changes the proportion of three quinnones and other photoproducts. In the absence of oxygen, oxidation does not take place.

Adsorption of pyrene, phenanthrene, fluoranthene, anthracene, benzo(a) pyrene on coal fly ash, activated carbon and graphite particles results in ~~machivation~~ inactivation of these compounds against photochemical degradation. ADsorption of fluorene and other selected PAHs onto the above particles causes oxidation to occur in the dark to corresponding quinones or a ketone (60). Such a reaction is not observed when these compounds are adsorbed on glass, alumina or silica surfaces. Hence it is suggested that only compounds containing benzylic carbon atom undergo oxidation. Benzo(a)pyrene and perylene adsorbed on glass fiber filters and exposed to air contianing 1ppm NO_2 form nitro compounds.

Pyrene and benzo(a)pyrene were adsorbed on alumina, coal fly ash and silica gel particulates. The adsorbed compounds were then exposed to NO for six hours; NO_2, SO_2 and SO_3 individually each for 12 hours. Approximate concentrations of these NOx and SOx were 100 ppm. Reactions were carried out in presence of daylight and ultraviolet light. Under both exposures, only NO_2 and SO_3 reacted with the two compounds. Ultraviolet light did not significantly affect the reactions. Pyrene and benzo(a)pyrene, when reacted with NO_2, form mononitro compounds. With benzo(a)pyrene small amounts of oxidized benzo(a)pyrene and benzene are also detected. REaction products with SO_3 were not identified. Peaks corresponding to decomposition or oxidation of pyrene and benzo(a)pyrene were identified. Pyrene on alumina and fly ash showed similar reactivity. Reactions on silica gel were different. Aged reaction products of pyrene with NO_2 on silica gel on analysis indicated tentative presence of mono and dinitro pyrenes. One of the dinitropyrenes increased quantitatively, which may be as a result of conversion of mononitropyrene. Also disappearance of mononitropyrene by conversion rather than decomposition is suggested. The acidic surface and presence of HNO_3 on the surface of silica gel are considered favourable for nitration reaction. Inorganic nitrate, organic nitrate and a reduced nitrogen compound, were tentatively identified as products when pyrene adsorbed on coal fly ash was exposed to NO_2. The likely reduced nitrogen compound is suggested as a nitrile, amino or pyridino compound. Presence of nitric acid on coal fly ash surface is speculated.

Emission of PAHs as high temperature vapours into the atmosphere will cause rapid cooling of these vapours (63). This will result in condensation of PAH vapours on airborne particulates or form condensed PAH particles. These particles bound and condensed PAHs undergo atmospheric processes, which are undergone by airborne particulates. These include turbulent dispersion, transport by wind, removal by wet and dry deposition and impaction. The following dry and wet fluxes of PAHs into Lake Michigan are reproduced from the reference 63. Data are under assumed conditions, which are the following. Samples were collected during cruises in a ship.

PAHs are present on 1~~mm~~um size particles. wind velocity = 4.7m/second. PAH deposition velocity to water = 2 x 10^{-2} cms/second, ~~At~~ at the lower limit and = 3.2 x 10^{-2} cms/second at the upper limit. Total surface area of Lake Michigan = 5.7 x 10^3 meter^2. The dry deposition flux is given by deposition velocity x average concentration of aerosol x area of deposition. Assuming a scavenging ratio of 160, the wet deposition flux is calculated as Rx yearly rainfall x area. R is the concentration of PAH in rain which is obtained by concentration of PAH in air x ratio of density of air to density of water.

Dry Flux (10^5kg/yr) of PAH
to Lake Michigan

Compound	Northern 2/3 of Lake	Southern 1/3 of Lake
Fluorene	0.72-11.5	1.6-2.5
Phenanthrene	0.36-5.8	0.9-14
Anthracene	0.24-3.8	0.9-14
Fluoranthene	0.48-7.7	1.4-28
Pyrene	0.24-3.8	1.7-28
Benzo(a)anthracene	0.48-7.7	1.3-20
Perylene	0.24-3.8	2.1-33
Triphenylene	0.24-3.8	0.43-68
Benzo(a)pyrene	-	1.2-19
Benzo(ghi)perylene	-	2.8-44

Wet Flux (10^6kg/yr) of PAH

Compound	Northern 2/3 of Lake	Southern 1/3 of Lake
Fluorene	1.1	2.4
Phenanthrene	0.57	1.3
Anthracene	0.37	1.3
Fluoranthene	0.73	2.0
Pyrene	0.37	2.6
Benzo(a)anthracene	0.73	1.8
Perylene	0.37	3.1
Triphenylene	0.37	0.65
Benzo(a)pyrene	-	1.8
Benzo(ghi)perylene	-	33.

~~than average~~ during inversion. Benzo(a)pyrene levels were found ~~to be~~ higher and when wind direction was from urban centers. A ~~Another~~ study has indicated that benzo(a)pyrene levels to vary inversely with the height of inversion layer. A linear relationship was observed.

A POM mixture placed on filter paper and allowed to stand for 30 days at room temperature showed substantial losses of fluoranthene and pyrene; up to about 75% of the initial concentration of each. The following half lives data are reproduced from the reference 96. Concentrations of alkylperoxyl radical and singlet oxygen are as same for air.

Compound	Alkylperoxy Radical	Half lives (hrs) in Air Singlet Oxygen	Ozone (2 x 10M)
Anthracene	$3.8x10^4$	5	–
Phenanthrene	$2x10^8$	–	–
Pyrene	$2.4x10^5$	—	$5.6x10^2$
Perylene	$3.8x10^4$	—	—
Benzopyrene	$2.4x10^5$	5	$8.7x10^2$
Benzanthracene		10	$3.7x10^2$
Dibenzanthracene		<5	$3.4x10^2$

All the above compounds have half lives less than 0.5 hrs in presence of chlorine; medium is unspecified. All the above compounds have half lives of approximately 10 hrs in presence of hydroperoxy radical; medium is unspecified.

Variations in half life under dark conditions

Ozone (ppm)	Benzo(a)pyrene	Benzo(b) Fluoranthene	Benzo(k) fluoranthene
0.19	0.62	52.7	34.9
0.70	0.40	10.8	13.8
2.29	0.30	2.9	3.3

Benzo(a)pyrene underwent degradation when it was drawn through a filter with SOx and NOx under simulated smog conditions. Degradation was greater with NOx than with SOx. The rate increased further in presence of NOx, SOX and Ozone. Benzo(a)pyrene degradation has been found to be greater than benzo(k)fluoranthene and benzo(b)fluoranthene. Atmospheric POM concentrations show a declining trend on the basis of ambient benzo(a)pyrene concentrations data recorded 10 years ago (96). Atmospheric residence time of POMs in winter has been found to be shorter than in summer. Average values are 35 to 80 hours and 100 to 200 hours respectively. POMs from emission sources are retained within 2 km of the atmosphere. They can be transported to distances as great as 1000 km. A 20-fold increase in local concentration in Norway was measured when winds in winter were from the direction of industrial areas of Western Europe. This was not observed in summer. Atmospheric transport is dependent on temperature inversions which affect movement of air. A 1976 Ontario Ministry of the Environment report indicates benzo(a)pyrene levels to be 117 to 350% greater than average during inversion. B(a)P levels were found to be higher when the wind direction was from urban centers. Benzo(a)pyrene and benz(a)anthracene levels were relatively high. PAHs origins include anthropogenic combustion processes. Transformations of vapour phase to particulates occur. PAHs residence times in air are long; principal removal process is impaction. Fluxes of PAHs from air to water are significant but slow.

PAHs are components of atmospheric polycylic organic matter (POM). Polycylic organic matter results from incomplete combustion which may be anthropogenic and natural of origin. POMs are also synthesized by bacteria. Atmospheric POMs undergo photochemical degradation, chemical oxidation and deposition. Chemical oxidation is significant in presence of high concentrations of oxidants. Existance of vapour phase POMS has been suggested. Equilibrium vapour phase concentration of POM such as benzo(a)pyrene is significant. Larger concentrations of POMs, other than that can be accounted for by adsorption on surfaces, have been found. POMs have been found to be very reactive in presence of oxidants. In presence of ozone, in dark, under laboratory conditions half lives of PAHs present on POms were found to vary significantly, with increasing concentrations of ozone. The initial rate was high, the rate was dependent on the surface area; multilayered adsorption and adsorption within the interstitial pores modified the rate of disappearance to 1.5% per hour. The following data are reproduced from the reference 96. Units of PAHs are unavailable.

Half lives in hours in simulated
daylight using quartz lamp
in presence of ozone

Compound	0.ppm	0.19 ppm	0.70 ppm	2.28 ppm
Benzo(k)fluoranthene	14.1	3.9	3.1	0.9
Benzo(b)fluoranthene	8.7	4.2	3.6	1.9
Benzo(a)pyrene	5.3	0.58	0.20	0.08

On theoretical basis under assumed conditions, benzo(a)pyrene is found to be removed from the atmosphere with a half life of 1.4 years. Included in the assumptions are an annual rainfall of 0.75 meters and a homogeneous atmosphere of height of 8 km. For benzo(a)pyrene adsorbed on aerosols/ atmospheric life time in days is calculated to be 7.9 days. The assumptions include an average tropospheric aerosol life time of 7 days; fraction of benzo(a)pyrene adsorbed on aerosols is 0.89. A particulate to gaseous ratio of 7.47 has been measured for benzo(a)pyrene (~~94~~ 99). Assuming background concentrations of OH and O_3 are 1×10^6 and 1×10^{12} molecules/cm^3 respectively. And room temperature reaction rate constants are valid at ambient temperature. Benzo(a)pyrene has been found to have an atmospheric residence time of 0.8 days. This is the estimated time for the compound to reduce to 1/e of its initial concentration. Photolysis probability is indicated as possible for having a chromophore which is likely to absorb light within the solar spectrum. The compound has a saturation vapour presence of 5.46×10^{-9} torr. Low saturation vapour pressure compounds are likely to be adsorbed on atmospheric aerosols on comparison with presence in the gaseous phase. On this basis, the compound has been rated as probable for physical removal probability. The likely photochemical oxidation product of benzo(a) pyrene is indicated as benzo(a)pyrene-1,6-quinone (99).

Dibenz(a,h)anthracene undergoes decomposition in urban air (136). ~~When~~ Irradiat~~ed~~ion with sunshine for one hour resulted in some decomposition, with longer irradiation resulting in removal of reactive intermediates. Increased rate of decomposition with additional products formation is observed in presence of sulphur dioxide (1975 reference; 136).

In an aquatic medium with a current velocity of 1 meter/second and a wind velocity of 4 meters/second; anthracene has a volatisation half life of 300 hours (136). ~~W~~with Henry's constant of 00.0027±0.0001 at 25° C and stable conditions. With a Henry's Constant of 1.2 x 10^{-3} under normal conditions at a stream depth of 1 meter; the half life of anthracene was calculated to be less than 100 hours (136). Increase in wind velocity en~~tr~~hances volatilisation. Photolysis half life of anthracene in aqueous solution and exposed to midsummer midday sunlight has been measured as 35 minutes at an initial concentration of 210 ppb. (136). The corresponding midsummer photolysis rate is expected to be about 0.36 times the midsummer midday rate and the corresponding winter rate is expected to be 0.12 times the midsummer midday rate. (136). [continued on page 229)

Concentrations of these compounds collected were reduced on addition of NO_2. Significant decrease in concentrations of phenanthrene, chrysene/triphenylene, benzo(b,j and k)fluoranthenes were not observed. These compounds are therefore not reactive. Benzo(e)pyrene and fluoranthene were of intermediate reactivity. Concentrations data of selected PAHs with and without the additions of NO_2, HNO_2, HNO_3 are given in the reference 69. No conclusive evidence was obtained upon the addition of ozone. Exposure to 1 ppm NO_2 resulted in reduction of benzo(a)anthracene ~~by~~ 20%; benzo(a)pyrene by 35% and perylene by 35%. 10-nitro benzo(a)anthracene and nitriben~~20~~zo(a)pyrene were tentatively identified. Nitropyrene was also detected. No nitroperylene was detected. In presence of HNO_3, benzo(a)pyrene decreased by 95%; benzo(a)anthracene and perylene decreased by 55% and benzo(ghi) perylene decreased by 20%. In the fraction containing mononitro compounds, 3-nitropyrene, nitrofluoranthene or pyrene, 10-nitrobenzo(a)anthracene and nitrobenzo(a)pyrene were tentatively identified.

~~3-nitropyrene, nitrofluoranthene or pyrene, 10-nitrobenzo(a)anthracene and nitrobenzo(a)pyrene were tentatively identified.~~

The corresponding half lives are 1.6 hours in summer and 4.8 hours in winter, at 35°N latitude. Labelled anthracene on exposure to sunlight underwent photooxidation to more polar products (136). Anthracene adsorbed on the plates in presence of sunlight has been observed to be photooxidized tentatively to anthraquinone. Anthracene adsorbed on coal fly ash has been found to be resisant to photooxidation. Coal fly ash adsorbed anthracene was reduced by 15% on exposure to xenon arc lamp for 24 hours. Anthracene adsorbed on to coal fly ashes from the vapour phase has also been found to be resistant to photooxidation. 9,10-anthraquinone is the expected major photooxidized product of anthracene. Anthracene adsorbed on to atmospheric particulates from the vapour phase undergoes photodecomposition. A sample of atmospheric particulates containing adsorbed anthracene, formed by subliming anthracene, was exposed to sunlight for 4 days. Anthracene amount decreased to 10% of its original value. Four degradation products were identified with one constituting 2-7% of decomposed anthracene. It was identified as an endoperoxide.

Atmospheric reactivity of selected PAHs was studied by addition of NO_2, and ozone during the sampling process to the volume of ambient air collected. NO_2 added was expected to contain small amounts of nitric acid. Pyrene, benzo(a)pyrene and benzo(a)anthracene were found to be reactive

(continued as the last paragraph on page 228)

TOXICITY

Mutagenicity test results and carcinogenicity test results are summarised separately in table form elsewhere in this section. Other biological effects are included in the following, which also includes summarisation of some studies describing mutagenic and carcinogenic effects.

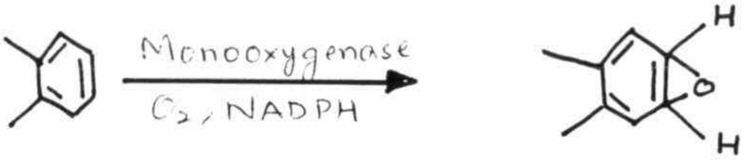
Carcinogenicity and mutagenicity of automobile exhausts are attributed to PAHs and substituted PAHs present in the exhausts. Bioassay studies have indicated that nitroPAHs contribute significantly to direct acting mutagenic effects of diesel particulate organic extracts in salmonella typhimurium strains, TA98 in particular.

A case study of iron foundry workers in Finland associates increased risk of lung cancer with exposures of high concentrations of PAHs in air (2). 51 cases of lung cancer were detected among 3876 men. 29 men were involved in work requiring exposure to high concentrations of PAH. The corresponding number for the control group was 21.93 men. The normal expected value was 18. Benzo(a)pyrene levels in the foundry atmosphere ranged from 0.2 to 72 ~~mg~~ µg/m^3 in air and 0.04 ~~mg~~ µg/mg to 0.4 ~~mg~~ µg/mg in dust.

PAHs are transformed to mutagenic and carcinogenic active species by mammalian metabolising enzymes. Epoxides are usually formed. Enzymes present in liver, lung and epithelial bronchial cells in man are capable of such transformations.

The transformed species can form covalent bonds with DNA, RNA and albumin (11). The bonding characteristics have been found to be related to cellular activity and carcinogenicity of the chemical. Mouse prostate gland cell cultures on treatment with PAHs have been found to undergo malignant changes. Upon transplantation of these cells into live animals, tumor formations are observed.

Some carcinogenic PAHs have been found to intercalate between DNA bases, which is attributed to the carcinogenic activity of the compound. The covalent bonds are believed to enhance the carcinogenic effect. The end matabolites of carcinogenic PAHs have been found to cause chromosomal aberrations in rat cell culture. The noncarcinogenici~~ty~~ PAHs do not cause such an effect (11). The enzymes, monooxygenases, which convert PAHs to their epoxides are of two classes; Cytochrome P450 and Cytochrome P448. The reaction is catalyzed with a coenzyme; reduced nicotinamide adenine dinucleotide phosphate (NADPH). (reference 134)



Phenols, dihydrodiols, quinones and higher oxidized PAHs are likely metabolites of PAHs. On incubation with rat liver enzyme, the following number of metabolites given in parentheses have been detected for the following PAHs. Phenanthrene (2); fluoranthene (6); pyrene (6); benz(a) anthracene (6); chrysene (2); cyclop~~ar~~enta(c,d)pyrene (6); benzo(a)pyrene (2); benzo(e)pyrene (2); benzo(b)fluoranthene (3); benzo(k)fluoranthene (-); indeno (1,2,3-cd)pyrene (-); benzo(ghi)perylene (2). 5,6-, 8,9-, 10,11- dihydrodiols have been detected as metabolites of benzo(a)pyrene.

Induction of monooxygenases in rat liver is observed when PAHs are applied intraperitoneally to the rat. Some PAHs like benzofluoranthenes and chrysene are strong inducers; some like benzo(e)pyrene and pyrene are not strong inducers or show little inducing potency. A measure of inducing potency, measured as ratio of benzo(a)anthracene turnover of induced animals to that of noninduced animals, on treatment with various PAHs are the following (134).

Inducer	Ratio of induced to noninduced:
None	1.0
Benz(a)anthracene	6.5
Pyrene	0.4
Chrysene	9.1
Benzo(a)pyrene	5.0
Benzo(e)pyrene	1.6
Benzo(b)fluoranthene	4.1
Benzo(j)fluoranthene	6.5
Benzo(k)fluoranthene	3.4

The % turnover for various PAHs without and after treatment with benzo(k) fluoranthene were the following:

PAH	% turnover without induction	% turnover after induction with B(k)F
Fluoranthene	21.0	45.0
Chrysene	0.8	25.0
Benz(a)anthracene	7.0	23.8
Pyrene	22.5	47.7
Benzo(b)fluoranthene	6.6	62.7
Benzo(j)fluoranthene	2.8	21.0
Benzo(a)pyrene	2.0	46.2
Benzo(e)pyrene	1.0	57.3
Indeno(1,2,3-cd)pyrene	1.0	55.0
Benzo(ghi)perylene	0.0	0.0

Aromatic hydroxylase present in the tissues of mammals is another enzyme which can activate or detoxify PAHs. The tissues include the liver, lungs and alveolar tissues. This enzyme can be induced by prior administration of PAHs. Mutagenic activity of azaarenes are reported to be similar to the PAH analogs. The activity is found to depend on the number of rings.

Tumor formations have been observed in mice in skin painting studies with PAHs; especially at the site of application. Other systemic effects that have been observed are; changes in blood, spleen, lymph nodes and bone marrow (134).

In an experimental study (18), 1-nitropyrene, 1,6-dinitropyrene and benzo(a)pyrene were found to be able to induce unscheduled DNA synthesis in human tracheal epithelial cells collected from human tissues of patients with lung cancer. The induction rate measured as average number of grains per nucleus was 3 for 1-nitropyrene at a dose of 10^{-4}M, 0.5 for benzo(a)pyrene at a dose of 4×10^{-5}M and 14 for 1,6-dinitropyrene at a dose of 10^{-4}M.

Intratracheal instillation of benzo(a)pyrene coated on ferric oxide particles in Syrian hamsters produced a carcinogenic effect similar to humans in the respiratory tract epithelium. The cancer induction was dependent on benzo(a)pyrene retention in the respiratory tract. Experiments have indicated that benzo(a)pyrene coated on aluminum oxide, gallium oxide and ferric oxide particles are retained in the lung for longer periods than pure benzo(a)pyrene by intratracheal administration.

Nose only inhalation study with radiolabelled 1-nitropyrene on gallium oxide and in pure form indicated rapid removal as measured by radioactivity. The results are in contrast to B(a)P results.

The toxic effect exerted by the adsorbed compound depends on the property of the biological fluid to extract this compound from the adsorbant. About 100 mg of benzo(a)pyrene was adsorbed on 900 mg of activated charcoal and then incorporated into beeswax-pellets. (25) These pellets were instilled into the trachea of rats. T~~he release~~ Benzo(a)pyrene conjugates produced by human pulmonary alveolar macrophages. are the following

Benzo(a)pyrene conjugates produced by human pulmonary alveolar macrophag

		Conjugate produced; p moles conjugate per 10^6 viable cells per 24 hours		
Volunteer	Induction	Sulphate	Glucuromide	Glutathrone
NS-1	C	59.1	2.0	11.2
	c/se	76.0	1.2	14.9
NS-2	C	27.3	0.4	10.0
	BA	39.7	6.3	17.0
	BA/Se	59.4	2.2	25.5
NS-3	C	7.8	2.7	17.3
	BA	9.3	1.1	24.2
	BA/Se	7.2	1.4	34.9
NS-4	C	16.4	10.8	15.1
	BA	18.1	29.9	20.3
	C/S	17.2	24.3	14.0
	BA/S	19.4	31.4	34.0
	C/Se	18.8	20.7	18.5
	BA/Se	29.3	23.9	30.6
S-1	C	26.8	19.1	22.3
	C/Se	28.5	5.5	42.1
	BA	10.1	2.1	53.3
S-2	C	26.8	19.1	22.3
	BA	42.4	23.0	25.9
	C/S	53.9	18.7	21.3
	BA/S	95.4	23.4	28.7
S-2	C/Se	39.3	16.2	21.1
	BA/Se	64.1	10.4	33.4

The release rate ~~Rate~~ of benzo(a)pyrene was observed to be 2.8±0.06% per day, at the highest concentration levels. At smaller concentrations, the initial release was rapid and most of the compound was released in the first two weeks, after implantation. No significant neoplastic effects were observed in the study (25).

In a mutagenicity test assay with Chinese hamster V79 cells from rat liver, lung, kidney and bladder the following metabolites of benzo(a)pyrene were identified (27). A pre-9,10-diol., 9,10-diol; -4,5-diol; -7,8-diol; -1,6-, -3,6-, -6,12- quinones; -9-phenol; -3-phenol. The total conjugated and unconjugated metabolites produced in various tissues were of the order lung>liver>bladder>kidney. In a study with human pulmonary alveolar macrophages, two major types of metabolites of benzo(a)pyrene were identified; the sulfate and the glutathione. The macrophages were collected from smoking and nonsmoking volunteers. The sulfate was the major matebolite. Selenium and sulphur enhanced sulfate conjugation and glutathione conjugation. The effect on glucuronide conjugate was variable. Data from the reference 20 are reproduced on the ~~following~~ preceding page. The following are the explanations of the keys. C-noninduced; BA-induced with benzanthracene; C/S-non-induced and cultured with NA_2SO_3; BA/S-benzanthracene induced and cultured with NA_2SO_3; C/Se-non-induced and cultured with NA_2SO_3; BA/Se - benzanthracene induced and cultured with NA_2SO_3; S-cigarette smoker; NS-nonsmoker.

Cyclopenta(c,d)pyrene was metabolized to trans-cyclopenta(c,d)pyrene -3,4-diol as the major metabolite in a mouse lymphoma cell metabolism study (41). The product may be formed by hydration of cyclopenta(c,d)pyrene -3,4-oxide in presence of enzymes. The product represented more than half the total metabolites formed. In the same study, mouse embryo fibroblasts metabolized the PAH to cyclopenta(c,d)pyrene -3,4-diol, unidentified phenolic and pre-3,4-diol metabolites. The 3,4-diol represented 76% of total metabolites formed. The following metabolites of benzo(a)pyrene were formed under identical conditions. Benzo(a)pyrene -9,10-diol; benzo(a) pyrene -7,8-diol; benzo(a)pyrene -1,6-quinone, benzo(a)pyrene -3,6-quinone; benzo(a)pyrene-3-phenol; benzo(a)pyrene-9-phenol. Benzo(a)pyrene-7,8-diol represented 22% of total benzo(a)pyrene metabolites. Benzo(a)pyrene metabolism was six times faster than cyclopenta (c,d)pyrene metabolism. Cyclopenta (c,d) pyrene -3,4-oxide has been found to be a direct acting mutagen in a mouse cells mutagenicity test (27). In mouse embryo fibroblasts transformation assay; cyclopenta (c,d)pyrene was found to have lesser cellular toxicity than benzo(a)pyrene and greater cellular toxicity than cyclopenta (c,d)pyrene-3,4-oxide. Benzo(a)pyrene -4,5-oxide was also relatively nontoxic. Cyclopenta (c,d)pyrene -3,4-diol was identified as the major metabolite.

Microsomal oxidation of benz(a)a~~r~~cridine is found to form two k-region and non k-region dihydrodiols. Comparison with a sample of trans-3,4-dihydroxy -3,4-dihydrobenz(a)a~~r~~cridine suggested that the hydroxyl group in the non-k-region dihydrodiol is not in the -3,4- position. Pretreatment of rats with phenobarbital increased three times the k-region diol formation. Pretreatment of rats with benzo(k)fluoranthene increased non-k-region dihydrodiol formation about four times. The following are reproduced from the reference 31.

			Metabolites formed in n moles/mg microso~~und~~mal protein x 15 minutes by rat liver microsomes of normal and pretreated rats			
	Untreated		Phenobarbital Treated		Benzo(k)fluoranthene Treated	
Metabolite	Lung	Liver	Lung	Liver	Lung	Liver
k-region dihydrodiol	2.8	7.9	3.9	22.8	1.4	5.3
Non-k-region dihydrodiol	1.6	4.4	0.6	3.8	4.2	15.8

Benz(c)a~~r~~cridine was metabolized by microsomes of untreated rats to a number of phenols, two dihydrodiols and one diphenol. The main metabolized compound was the k-region dihydrodiol. Pretreatment of rats increased the k-region dihydrodiol by a factor of 7. Three non-k-region dihydrodiols and two k-region triols were also detected. Only one phenol was formed. Total metabolites increased two times. Pretreatment of rats with 5,6-benzofl~~u~~a~~orone~~vone or benzo(k)fluoranthene increased total metabolites by factors of 3.9 and 2.8 respectively. Dihydrodiols and phenols formations were increased. Diphenols and triols were also formed. The following data are reproduced from the reference 31.

Metabolites formed in n moles/mg microsomal protein x 15 minutes by rat liver microsomes of normal, phenobarbital; 5,6-benzofl~~uorone~~avone or benzo(k) fluoranthene treated rats

Metabolite	Normal	Phenobarbital	5,6-Benzo flavone	Benzo(k) fluoranthene
Phenol I	2.2	0.3	1.6	0.6
Phenol II	4.2	-	7.4	3.0
Phenol III	3.0	-	4.9	2.9
Phenol IV	2.2	-	6.9	4.3
Phenol V	1.1	-	4.1	-
Diphenol I	1.3	-	1.3	0.6
Diphenol II	-	-	1.2	0.3
Diphenol III	-	-	3.9	2.1
k-region diol	5.5	36.7	23.3	17.6
Non-k-region diol I	1.2	2.0	1.0	Not available
Non-k-region diol II	-	0.6	11.8	11.7
Non-k-region diol III	-	1.1	2.8	9.5
k-region triol I	-	0.7	-	-
k-region triol II	-	0.8	3.6	1.0
Non-k-region triol I	-	-	1.2	-
Non-k-region triol II	-	-	-	2.2
Phenol-N-oxide	-	-	1.2	-
Diphenol-N-oxide	-	-	2.3	-

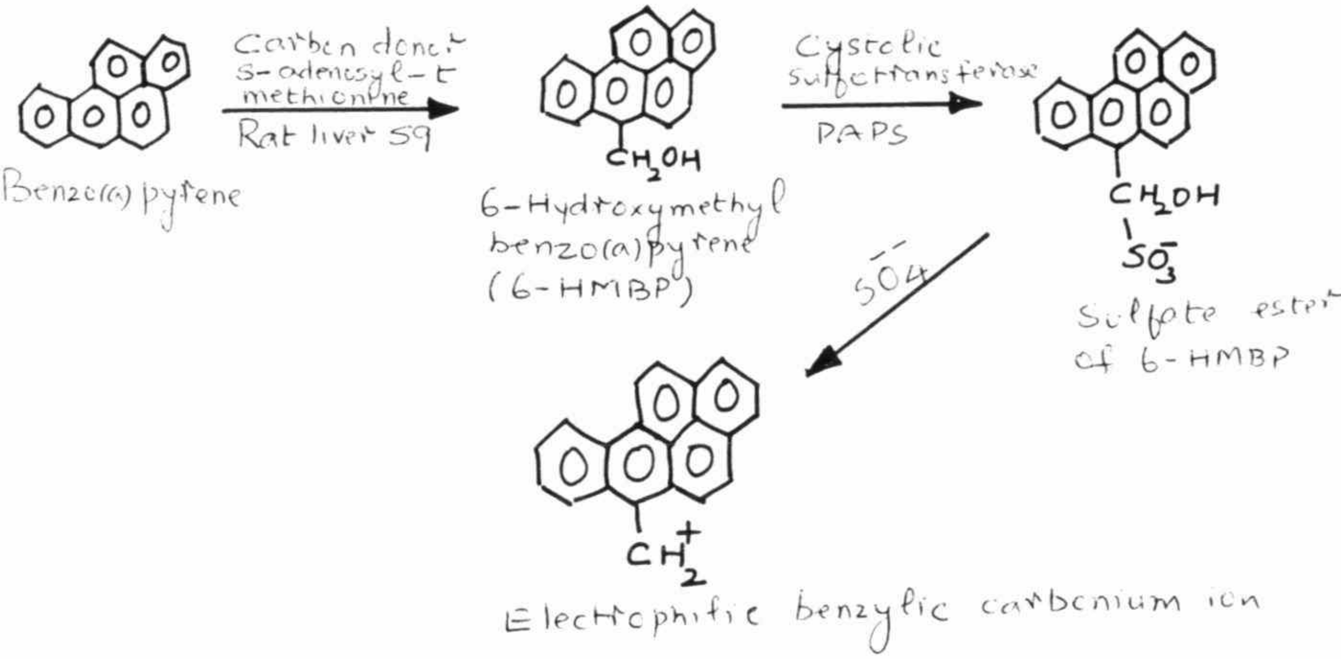
Binding studies of cyclopenta (c,d)pyrene have indicated that at 4 hours, the compound bound to DNA is about one third of that bound to RNA. After

24 hours treatment, binding of the compound to both DNA and RNA increased about four fold. Binding of benzo(a)pyrene was found to be high relatively. A decrease of about 2.5 times to DNA was observed between 4 and 24 hours.

Benzo(a)pyrene binds to cytoplasmic lipoprotein forming a complex (39). It is transported to the nucleus of the cell. The metabolised product is identified as benzo(a)pyrene -7,8-diol-epoxide-1-deoxygunanosine adduct in the cells. Photoactivated benzo(a)pyrene binds to DNA covalently (38). Increased photooxidation of the compound causes increased DNA damage such as alkaline lability and guanine destruction. Study with human skin fibroblasts normal cells and xeroderma pigmentosum cells have shown maximum cytotoxic effects near ultraviolet radiation. Xeroderma cells were more sensitive to toxic effects with far ultraviolet radiation, which is attributed to certain deficiency in their excision repair process. In the study, toxic effects on xeroderma cells and normal cells were not signifcantly different. Part of the toxic effects may be caused by benzo(a)pyrene quinones through formation of a 6-phenoxy radical intermediate or subsequent oxidation-reduction process involving hydroquinones and semiquinone radicals (38).

Rat liver microsomes metabolize dibenzo(a,i) pyrene to diols (35). Two diols were identified in the study which were: 3,4-dihydro-3,4-dihydroxydibenzo (a,i)pyrene and 1,2-dihydro-1,2-dihydroxy dibenzo(a,i)pyrene. Two diols were also identified as metabolized products of dibenzo (a,h)pyrene. These were; 3,4-dihydro-3,4-dihydroxy dibenzo(a,h)pyrene and 1,2-dihydro-1,2-dihydroxy dibenzo (a,h)pyrene. Metabolism of these dibenzo pyrenes may ~~remit~~ result in the formation of bay region dihydrodiol epoxides as intermediates such as the 1,2-dihydrodiol-3,4-epoxide of dibenzo(a,h) pyrene.

The following is a suggested metabolisation scheme for benzo(a)pyrene in presence of rat liver S9 enzyme.



6-HMBP forms a highly mutagenic metabolite in the presence of a S-105 liver cystolic fraction and a sulfotransferase-PAPS generating system. Significant differences are observed with dialysed and nondialysed cystolic fraction S-105 in presence of cofactors. With nondialysed cystolic fraction and absence of NA_2SO_4 mutagenicity was reduced by 66% in salmonella TA98 test. Dialysis in the absence of NA_2SO_4 also reduces mutagenicity. 6-HMBP is biosynthesized in the system. ATP mediates part of the mutagenic process. It mediates binding of 6-HMBP to DNA. In the absence of ATP, 6-HMBP was not mutagenic in the salmonella TA98 test; merely suggesting the mutagenic sulfate ester of 6-HMBP is formed by the sulfotransferase PAPS system. The acetate ester of 6-HMBP is a strong direct acting mutagen. It is hypothesized in the study (57) that benzylic reactive esters of meso-hydroxyalkyl metabolites are direct acting mutagens and end carcinogens. The reactive site at the meso position plays an important role in the carcinogenic process of the PAHs. Formation of a mesobenzylic reactive ester or a mesobenzylic carbonium ion is an important pathway of metabolic activation to the end product carcinogen.

DNA binding characteristic of selected PAHs has been found to correlate with carcinogenic properties of the compounds (61). This is based on a study using culture system collected from human bronchus, colon, esophagus, peripheral lung and trachea. Specimens were collected from lesions which were cancerous or benign at the time of autopsy soon after death. Metabolism of benzo(a)pyrene is mediated by cytochrome P-450 and aryl hydrocarbon hydroxylase enzymes. Benzo(a)pyrene-7,8-diol epoxide is formed through trans-7,8-diol, which react with DNA forming the DNA-adduct. The reaction was observed in all tissues. Highest mean level of DNA adduct occured in bronchus, which was 22±24 p. moles per 10 mg. DNA. The intermediate level was in trachea and esophagus. Lowest level was observed in the colon. The levels varied with variations in individuals with 75 fold in brochus, 100 fold in esophagus and 135 fold in colon. An unimodal distribution was observed in the data. Activity and inducibility of arylhydrocarbon hydroxylase are dependent on heritable qualities. and single or few polymorphic genes control inducibility.

Changes in physiology of cells and tissue affect adduct formation. In a study with a patient, a 2 to 3 fold increased level of binding was observed in the duodenum than in the transverse colon. Tests with human colon tissue from the same patient after a 1-month interval indicated no differences in the level of binding of B(a)P to DNA. Variations in arylhydrocarbon hydroxylase was observed. Significant difference in PAH binding of tracheobronchial tract or esophagus was not observed. A positive correlation was found among the binding levels of benzo(a) pyrene to bronchial, colonic and esophageal tissues. Hence it is suggested that the ability of one cell type to bind benzo(a)pyrene metabolite to DNA may be considered as an overall ability to activate benzo(a)pyrene to form benzo(a)pyrene metabolite-DNA adduct. This may be used to identify individuals with a high risk for PAH induced cancer or chemically induced cancer in general.

The major adduct identified by HPLC is given as the product formed from addition of a (7β, 8α)-dihydroxy-(9α, 10α)-epoxy-7,8,9,10-tetrahydrobenzo(a)pyrene (BPDEI) to the exocyclic 2-amino group of guanine. BPDEI exists in two stereoisomeric forms; the 7R form and the 7S form. The 7R form is the major compound in cultured human tissues.

Distribution of adducts is dependent on species. The 7S-BPDEI is the major active form in the samples from the trachea of rats. The adduct formation is dependent on a secondary structure of DNA. Preferential formation of 7S form with guanine in the double stranded DNA and equal reactivity with guanine in single stranded DNA have been observed. Minor amounts of adducts from the addition of (7β, 8α) - dihydroxy-(9β, 10β) - epoxy -7,8,9,10-tetrahydrobenzo(a)pyrene (BPDEII) were also formed.

Amounts were variable with different patients. The importance of B(a)P-DNA adduct formation with respect to toxicity of B(a)P is not known. Similar adduct formation has been observed in animals in which benzo(a) pyrene has been found to be carcinogenic.

The benzo(a)pyrene metabolites consisted of water soluble metabolites and metabolites soluble in organic solvents. The water soluble metabolites were in lower proportion. The following data, in unspecified units, are reproduced from the reference 61.

B(a)P - DNA adducts

Tissue	B(a)P-Cytosine	7S-BPDEI Guanine	7R-BPDEI Guanine	BPDEII Guanine
Bronchus	17	21	56	7
Colon	-	-	92±12	8±12
Esophagus	28	7	59	5.5

Total metabolites of benzo(a)pyrene
Cultured by human tissues

	Bronchus	Trachea	Colon	Esophagus
Total Metaabolites	1335±551	1092±256	260±186	381±133
Organic Extractables	834±459	783±227	222±155	360±212
Water Soluble	501±276	309±115	36±16	164±280
Sulfates	44±8	56±5	45±5	34±12
Glucronides	7±2	12±5	7±5	78±9
Glutathione	51±8	32±9	48±7	48±10

Glutathione conjugates and sulfate esters were identified as the major water soluble metabolites. Glucuronides were detected in small amounts. Metabolites identified as soluble in organic solvents consisted of diols, tetrols and small amounts of phenols. Equal amounts of 4,5-diol and 7,8-diol were detected in trachea and bronchus while higher amounts of 7,8-diol were present in cultured colon. Tetrols were in greater proportion than diols in bronchus and trachea, than in esophagus and colon. Enzymes present in tracheal-bronchial tissues further metabolize diols. Trans-7,8-diol is more readily metabolized and bound to DNA ~~thn~~ than trans-9,10-diol, trans-4,5-diol or benzo(a)pyrene

Metabolites soluble in organic solvents were subject to individual variations. Some differences were observed in the metabolites of benzo(a)pyrene in the bronchial tissues of patients with lung cancer, and from normal patients. Quantitative information in unspecified units on metabolites soluble in organic solvents and formed in trachea, bronchus, colon and esophagus are given in the reference 61. The following are the metabolites identified. 7,10/8,9-tetrol; 7,9/10,8-tetrol; 7,9/10,8-tetrol; 7,8,9-triol; trans-9,10-diol; trans-4,5-diol; trans-7,8-diol; 3-hydroxy compound; 9-hydroxy compound; unidentified products.

Some chemicals inhibit neoplastic effects of benzo(a)pyrene. Some chemicals enhance benzo(a)pyrene - DNA adduct formation. Bile acids enhance colonic DNA and benzo(a)pyrene adduct formation. Bile acids may have an effect on benzo(a)pyrene - mucosal cells interactions.

Labelled 1-nitropyrene and 1,8-dinitropyrene have been found to covalently bind to DNA (66). In the study extracts of salmonella typhimurium TA98 was incubated with tritiated 1-nitro pyrene or 1,8-dinitropyrene. The binding of 1-nitropyrene to DNA was found to be 2.6 molecules per 10^6 nucleotides. The binding of 1,8-dinitropyrene was 4.3 times higher. Major metabolites of 1-nitropyrene were identified as 1-aminopyrene and 1-N-acetylaminopyrene. The major metabolite of 1,8-dinitropyrene was identified as a pink metabolite which was 1-amino-8-nitropyrene. 1,8-diaminopyrene was also identified as a metabolite. In the study 1,8-dinitropyrene disappearance was 2.5 times greater than 1-nitropyrene. The following adducts formation pathways have been suggested in the reference 66.

1-Nitropyrene

$$\mathrm{Pyr\text{-}NO_2} \longrightarrow [\mathrm{Pyr\text{-}N{=}O}] \longrightarrow [\mathrm{Pyr\text{-}NH\text{-}OH}]$$

$$[\mathrm{Pyr\text{-}NH\text{-}OH}] \longrightarrow \mathrm{Pyr\text{-}NHAC}$$

$$[\mathrm{Pyr\text{-}NH\text{-}OH}] \longrightarrow \mathrm{Pyr\text{-}NH} \xrightarrow{\mathrm{DNA}} \text{Adducts.}$$

1,8-Dinitropyrene

$$[O_2N-\mathrm{Py}^{t}-NO_2] \longrightarrow [NO_2-\mathrm{Py}^{t}-NHOH]$$

$$[NO_2-\mathrm{Py}^{t}-NHOH] \longrightarrow \text{Adducts.}$$

$$[NO_2-\mathrm{Py}^{t}-NHOH] \longrightarrow NO_2-\mathrm{Py}^{t}-NH_2 \longrightarrow [HONH-\mathrm{Py}^{t}-NH_2]$$

$$[HONH-\mathrm{Py}^{t}-NH_2] \longrightarrow [\overset{+}{NH}-\mathrm{Py}^{t}-NH_2] \xrightarrow{DNA} \text{Adducts.}$$

$$[HONH-\mathrm{Py}^{t}-NH_2] \longrightarrow NH_2-\mathrm{Py}^{t}-NH_2$$

In a hepatocyte primary culture repair test system for measurement of DNA damage induced by chemicals; benzo(a)pyrene and debinz(a,c)anthracene indicated positive responses. Biphenyl, anthracene, dibenz(a,h)anthracene, phenanthrene, pyrene and benzo(e)pyrene indicated negative results. Analysis was done by an auto radiographic procedure by counting the number of silver grains over the nucleus. The following data are reproduced from the reference 84.

	Concentration (n moles/ml)		Nuclear Grains	Silver Counted
Compound	Active Range	Concentration Counted	Treated	Control
Benzo(a)pyrene	50-5	5	11.7±1.0	-1.2±0.3
Dibenz(a,c)anthracene	1000-50	100	11.3±3.5	-0.3±1.4
Biphenyl	None	100	0.1±3.1	0.3±2.0
Anthracene	None	100	-0.6±1.4	-0.1±2.5
Dibenz(a,h)anthracene	None	100	1.2±1.7	0.5±0.6
Phenanthrene	None	100	0.3±1.1	0.0±0.8

Concentration (n moles/ml)

Compound	Active Range	Concentration Counted	Nuclear Grains Treated	Silver Counted Control
Pyrene	None	500	11.7±1.0	-1.2±0.3
Benzo(e)pyrene	None	100	-0.11±0.9	0.00±1.2
Banz(a)anthracene	1000-50	1000	16.7±4.3	-0.7±1.2

The negative responses may also be due to insensitivity of hepatocyte cultures to the compounds. Compounds may be unavailable biologically or are not metabolically activated. Lack of adequate solubility can produce negative responses. Inhibition of unschedule DNA synthesis by inhibition of DNA repair enzymes will also result in negative responses. Benzo(a)pyrene tested for DNA synthesis inhibition test was found to inhibit DNA synthesis in the HeLa cells by 40% at a concentration of 0.82 x 10^{-6} molar in 2½ hours after removal of the compound from the cells.

Intraperitoneal administrations of benzo(a)pyrene and cigarette smoke condensate in rats were found to induce enzymes in the liver, lung and kidney tissues. Measurements were made for selected enzymes. (102) Aryl hydrocarbon hydroxylase was the major enzyme measured. PAHs are metabolized by this enzyme to arene oxides which undergo further enzymic and nonenzymic reactions to metabolites which may exert mutagenic, carcinogenic and other toxic effects. Induction of aryl hydrocarbon hydroxylase has been observed in the lung and kidneys of ~~administered 25 mg/kg dose of cigarette smoke condensate, the AHH increased gradually. In 90 day old rats, the increase was by a factor of 4. In older rats, the basal and induced AHH, as measured by activity, remained constant. The following are the ontogenetic variations observed in rats after administration of benzo(a)pyrene at doses of 1 mg/kg (low) and 80 mg/kg (high) intraperitoneally.~~

~~Rats~~ rats, mice and hamsters by cigarette smoke, the lung enzyme has been found to be much more sensitive than other enzymes to the inducing action of cigarette smoke. This enzyme is also induced by cigarette smoke in the placentas and pulmonary alveolar macrophages of smoking and nonsmoking women. Cigarette smoke does not affect the AHH activity in the liver.

In the study (102), Sprague Dawley rats were intraperitoneally injected with 3 successive doses at 24 hour intervals for 3 consecutive days. The doses of benzo(a)pyrene were 5mg/kg, 20mg/kg, and 50mg/kg. At 5 mg/kg, only the lung AHH was induced significantly. At 20mg/kg, both the lungs and kidneys AHHS were induced. At 50mg/kg AHH was induced in all three tissues, the lungs, kidneys and the liver.

Administration of 5mg/kg or 25mg/kg doses of cigarette smoke condensate in rats did not result in induction of AHH in the livers of foetus and 5 days old rats. Induction of AHH in the liver of 15 days old rats was observed, but was not observed in rats older than 30 days. AHH was not induced in the kidneys of foetus and young rats. It was induced in the kidneys of 15 days old rats. It was slightly induced in the kidneys of older rats at 25mg/kg dose. In the lung, AHH was not induced in the unweaned rats. In other rats, induction of AHH in the lung increased with age. In 15th to 90th days of birth of rats; the AHH in control rats which is the basal AHH decreased, In same days old rats. administered 25 mg/kg dose of cigarette smoke condensate, the AHH increased gradually. In 90 days old rats, the increase was by a factor of 4. In older rats, the basal and induced AHH, as measured by activity, remained constant. The following are the ontogenetic variations observed in rats after administration of benzo(a)pyrene at doses of 1mg/kg (low) and 80 mg/kg (high) intraperitoneally.

At high dose level, AHH was induced in the liver of all animals. At the low dose level, it was significantly induced only in 15 days old rats. In the kidney(s), the high dose induced AHH in all animals. The low dose induced AHH in unweaned animals. Significant induction by a factor of 4 was observed in 15 days old animals. Lung(s) of young rats was not sensitive to high doses of benzo(a)pyrene. AHH induction increased with age in the lung of rats with maximum induction in the adult animals. Low doses were similar to high doses, in AHH inducing efficiency. In 9 month old rats, the basal AHH was found to decrease but it remained inducable. The following data are from the reference 102.

Age (days) of rats	AHH activity (n moles/g. liver × hr) induced by benzo(a)pyrene		
	L=1mg/kg	HD=80mg/kg	Control
2.5	785	-	-
5.0	-	6981	678
15	2500	7912	1010
90	-	-	-
270	-	-	-

Two other enzymes related to cytochrome P450 and P448 were also studied. These were ethoxycoumarin deethylase and ethoxyresourfin deethylase. These enzymes were induced in the liver of 15 days old rats at the low dose of benzo(a)pyrene. These were induced by the high dose in all rats.

Low dose of benzo(a)pyrene induces ethoxyresourfin deethylase in the kidney(s) of 15 days old rats but not in the lung of these rats. The inducibility of this enzyme increases with age, with 3 fold increase in 30 day old rats; 5 fold increase in 3 month old rats. The low dose of 1mg/kg was found to be as efficient as the high dose of 80mg/kg in inducing this enzyme. Other enzymes that were measured with benzo(a)pyrene doses or 25mg/kg of cigarette smoke condensate were aldrin epoxidase, aminopyrine-N-demthylase, barzphetamine-N-demethylase, epoxide hydrolase, epoxide glutathione transferase. All these were induced in the liver, kidney and the lung.

The induction of enzymes after cigarette smoke uptake is attributed to presence of PAHs in cigarette smoke. Benzo(a)pyrene and cigarette smoke condensate have similar AHH induction characteristics. Powerful inducers, other than polycylic hydrocarbons, may be present in cigarette smoke condensate. A synergistic effect of cigarette smoke condensate constituents may exist in inducing AHH.

The non induction in adult animals in some cases may be due to presence of agents which have an inhibiting action on benzo(a)pyrene or cigarette smoke condensate inducing potential. Benzo(a)pyrene was found to exert weak toxic effects in a test using onion bulbs, allium cepa . Allium ~~epa~~ cepa contains mixed function oxidase system which metabolizes benzo(a)pyrene. The enzyme system is not in sufficient amounts to completely metabolize benzo(a)pyrene. Tests were performed with onion bulbs by the procedure described in reference 104 at benzo(a)pyrene concentrations of 0.5, 1, 5, 10 ~~mg~~ug/ml dissolved in acetone. Mean root length did not vary significantly from control at 0.5 and 1 ~~mg~~ug/ml. Significant reduction was observed at 10 ~~mg~~ug/ml. The following data are reproduced from the reference 104.

Treatment (ug/ml)		Mean root length after 5 days of treatment
Benzo(a)pyrene:	10	2.91±0.28
	5	5.58±0.3
	1	6.67±0.53
	0.5	6.57±0.20
Control (Tapwater)		7.18±0.5
Acentone	1%	4.95±0.46
	0.5%	6.85±0.57

Benzo(a)pyrene concentration of 10ug/ml was dissolved in 1% acetone. Other concentrations are in 0.5% acetone.

The compound was cytotoxic at high concentrations. The mitotic index varied from 3.7 at 10~~mg~~ug/ml to 5.2 at 0.5 ~~mg~~ug/ml. Controls had a mitotic index of 5.5. Data on various parameters indicative of cytotoxicity are the following: stickiness and bad looking chromosomes were significant in benzo(a)pyrene treated specimens.

	Benzo(a)pyrene treated						
Parameters	10	5	1	0.5	Acetone Treated 1%	Acetone Treated 0.5%	Control
Mitotic Index	3.7	4.9	5.5	5.2	4.3	5.1	5.5
Number of cells Analysed	500	500	-	-	500	500	500
Normal metaphases	52	44.8			54.8	56	500
Normal anaphases	28.7	31.6			30.2	29.0	25.4
Delayed anaphases	9.8	11.8			10.6	9.6	7.8
Stickiness	6.7	10.4			2.4	3.0	2.4
Bridges	1.0	0			0.4	1.6	1.8
Fragments	0.5	0.2			0.2	0.4	0.2
C-mitosis	0.8	0.0			0.4	0.2	0.6
Vagrant Chromosomes	0.5	1.2			1.0	0.2	0.2
Mitoses>2n	0	0			0	0	0.4
Mironuclei	+	+			+	+	-

Benzo(a)pyrene and cigarette smoke condensate have been found to exert cellular toxicity when rat lungs and trachea are exposed to these chemicals under laboratory conditions (105).Lungs from 17-18 day old fetal mice and tracheas from neonatal rats were grown in a suitable medium and exposed to benzo(a)pyrene and cigarette smoke condensate.

Lungs treated with benzo(a)pyrene or cigarette smoke condensate showed increased epithelial mitosis causing hyperplasia of the bronchial epithelium. In some areas, the hyperplastic epithelium consisted of proliferating basal cells underneath the original cells. In other areas, the top layer original cells were absent. The observed mitosis was four times more than the control value in lungs treated with benzo(a)pyrene and two times the control value in lungs treated with cigarette smoke condensate. In lungs treated with these chemicals and later transferred to the control medium, the cell proliferation and hyperplasia continues after the removal of the chemicals. The top layer of original cells is absent in most of the hyperplastic areas. The mitosis is six times the control value in benzo(a)pyrene treated lungs and more than three times the control value in cigarette smoke condensate treated lungs. Addition of a retinoid inhibits induction of mitosis by chemicals in the former. In the latter, addition of a retinoid for four days did not affect the normal incidence of mitosis. It reversed the increase resulting from the chemicals.

In rat trachea, benzo(a)pyrene induced proliferation of epithelium in the form of multilayered and folded epithelium. Number of goblet cells was reduced, cilia showed injury and were clumped. Squamous metaplasia was present in the epithelium of some trachea. These epitheliums also had keratinous strands. Cigarette smoke condensate caused similar but weaker effects.

Mitosis was increased four times the control value in benzo(a)pyrene treated trachea and three times the control value in cigarette smoke condensate treated trachea. Treatment of trachea with the chemicals and subsequent transfer to the control medium causes enhanced mitosis, six and four times the control value with benzo(a)pyrene and cigarette smoke condensate respectively. Treatment with a retinoid indicated effects similar to the effects in the lungs. Human fetal lungs have shown effects similar to mice lungs on treatment with benzo(a)pyrene and cigarette smoke condensate (105). Hamsters trachea have shown effects similar to rat trachea.

Smoke and particulates produced during welding operations during refitting of oil tankers represent a health hazard. The following are the sister chromatic exchange induction data from the reference 107. Air borne particulates samples were collected during flame cutting operation. The particulates were extracted with cyclohexane. The cyclohexane extract and the extract fractionated in to a PAH fraction were tested for sister chromanid exchange induction in mouse bone marrow cells after dissolving in olive oil.

Induction of SCEs in Foetal livers

Dose(B(a)P)	SCE/cell	
	Invivo	Invitro
0	9	8
1.0	-	13
3.0	-	12.5
10.2	-	13.0
75	10	
150	15	

Benzo(a)pyrene is metabolized to DNA damaging products. Foetal metabolism of benzo(a)pyrene also results in similar products. Passage of benzo(a) pyrene into the foetus during invivo exposure was limited, thereby resulting in relatively reduced foetal toxic effects. The following additional data are also from the reference 117. The dose range of benzo(a)pyrene was 300.0 - 600 uM/kg.

Induction of micronuclei/erythroblast/ uM/kg:	1.7×10^{-5}
Induction of SCEs/erythroblast/uM/kg :	8.0×10^{-3}
Induction of MNPCE :	2×10^{-5} micronuclei/uM/kg.
Induction of SCE(invivo) :	5.38×10^{-3} SCE/uM/kg
Induction of SCE(invitro) :	1.61 SCE/uM/kg
Ontogenic Potency :	3.62×10^{-3} to 5×10^{-2} frequency of tumor bearing animals/uM/kg
Ontogenic Potency, transplacental :	4.8×10^{-4} frequency of tumor bearing animals per uM/kg.
MNPCE induction, transplacental :	5.25×10^{-5} micronuclei per uM/kg.

foetuses per litter. Exposure to the chemical was started during the 16th day of gestation. For the sister chromatid exchange test, 2 pregnant animals per point were used for the invivo test. For the invitro test, 2 cultures containing 2 foetal livers were used. For the invivo test, exposure to the chemical started during the 15th day of gestation. The following were the observed results. Data are reproduced from the reference 117. Doses were administered intraperitoneally in corn oil for invivo tests and in dimethyl sulfoxide for invitro tests.

Micronucleated polychromatic erythrocytes (MNPCE) induction in maternal bone marrow and foetal liver

Agent	Damage/unit dose, probability of erythroblast forming acentric fragment: Maternal Bone Marrow	Damage/unit dose, probability of erythroblast forming acentric fragment: Foetal Liver	Radiation Equivalence: Maternal Bone Marrow	Radiation Equivalence: Foetal Liver
- radiation 2.5-50 rad	1 x 10^{-3}/rad	1 x 10^{-3}/rad		
Benzo(a)pyrene 300.0-1190.0 uM/kg	33 x 10^{-5} um/kg	1.7 x 10^{-5}uM/kg	30.0	58.0

Induction of sister chromatid exchanges (SCEs) in feotal mouse erythroblasts invivo

Dose(B(a)P	% MNPCE	SCE/cell
0	0	7.5
74	0.5	8.5
150	0.9	13.5
300	1.25	-

Compound	Dose (mg/kg body weight)	Sister chromatid Exchange/cell
Cyclohexane extract	0	-
of airborne	27.5	6.4
particulates	62.5	13.125
	120.0	12.25
PAH fraction of	0	4
the extract	164	7.5
	315	105
Cyclohexane extract	0	5.75
of smoke collected	164	9
from tanks	315	11.5

Mixtures of polyaromatic hydrocarbons have been found to inhibit the mutagenicity of some PAHs in the mixture. Mixtures of compounds isolated from coal derived oil were found to inhibit the mutagenic action of benzo(a)pyrene and other selected PAHs in salmonella mutagenicity assay with strain TA98 and ~~another~~ aroclor induced rat liver S9 or microsomes. The mixture also inhibited, S9 induced metabolism of benzo(a)pyrene and covalent binding of the metabolite to DNA in tests in a cell free system (114).

Micronucleated polychromatic erythrocytes and sister chromatid exchange induction by benzo(a)pyrene were tested in mice. Micronucleated polychromatic erythrocytes induction tests were done with 3 pregnant animals per point and 2-4 benzo(a)pyrene is metabolized by microsomes present in human fetal livers to phenolic metabolites (119) The microsomes were obtained from human foetuses of gestational age varying from 15 to 27 weeks. Microsomes from foetuses of nonsmoking women formed smaller quantities of phenols. No dihydrodiol metabolites were detected in the study (119). Microsomes obtained from midgestational and term placentas of smoking persons metabolized benzo(a)pyrene to hydrodiols and phenolic compounds. 9,10; 4,5-; 7,8-dihydrodiols; 9-phenol and 3-phenol were identified. quinones were not identified. Microsomes from the placentas of nonsmokers or 10 weeks gestation smokers did not metabolize benzo(a)pyrene. Total metabolites formation rate varied from 4 to 10 p. moles/min.mg with microsomes from midgestational placentas. 36 to 39% of metabolites were identified as dihydrodiols. The microsomes from term placentas also formed total metabolites at a rate of 4 to 10 p. moles/min.mg. 45 to 50% of total metabolites were dihydrodiols. Foetal livers from smokers showed higher enzymic activity in metabolizing benzo(a)pyrene.

Lung epithelial cells type II from rats metabolize benzo(a)pyrene to oxidized and conjugated metabolites. The major metabolite was identified as the benzo(a)pyrene -9,10-diol at a rate of 450 p.moles per 10^6cells per 24 hours of benzo(a)pyrene. Benzo(a)pyrene -7,8-diol and conjugated metabolites were identified at 10-20% of total benzo(a)pyrene metabolized. The rate was 100 p.moles per 10^6 cells per 24 hours of benzo(a)pyrene. Small quantities of glucuronide conjugate of benzo(a)pyrene -7,8-diol and benzo(a)pyrene -9-phenol were also identified. Sulfate conjugates were not identified. Lung epithelial cells of rats pretreated with benz(a)anthracene increased the formation of 7,8-, 9,10- diols and glucuronide conjugates of 7,8-diol and 9-phenol. The increase in total metabolites was four to five times that resulting from incubation in dimethyl sulfoxide. Higher concentrations of benz (a)anthracene and longer preincubation time did not significantly enhance metabolization of benzo(a)pyrene. The above indicated diols and conjugate metabolites of benzo(a)pyrene were also increased when the cells were pretreated with diesel exhaust particles extract and low BTU gasifier condensate. There was a dose dependent increase with a maximum beyond which no further increase in benzo(a)pyrene metabolites was observed. The concentration of diesel exhaust extract which caused maximum benzo(a)pyrene metabolite formation also caused 2 to 3 fold increase in benzo(a)pyrene that bound to the macromolecules in cells. No such increase in binding was observed when benz(a)anthracene and coal gasifier condensate were used.

Another study describing metabolism of benzo(a)pyrene by placental enzymes induced in cigarette smokers is the reference 122. Metabolism of benzo(a)pyrene in general results in an epoxide of benzo(a)pyrene. This epoxide further may undergo conjugation with glutathione. The reaction may be catalyzed by enzymes. It may undergo nonenzymatic rearrangement to phenol, NADPH and cytochrome P-450 mediated reduction to benzo(a)pyrene, Conversion in presence of epoxide hydrase to the corresponding dihydrodiols. phenols and dihydrodiols may conjugate with glucuronic acid and sulfate and become nontoxic. Dihydrodiols and benzo(a)pyrene -7,8-diol in particular, may be converted by mixed function oxidase system to the bay region diol epoxides, such as the benzo(a)pyrene -7,8-diol-9,10-oxide, which is considered to be an ultimate mutagenic carcinogenic and DNA binding metabolite. In the study in reference 122, the placental AHH activity was measured and was found to vary between individuals' smoking habits and in samples from the same individuals collected at different sites. Excellent agreement between data was observed between aryl hydrocarbon hydroxylase activity and benzo(a)pyrene phenol formation; and between benzo(a)pyrene phenol formation and benzo(a)pyrene -7,8-diol formation. Placental enzymes metabolize benzo(a)pyrene. Placental enzymes with high aryl hydrocarbon hydroxylase activity convert benzo(a)pyrene to DNA binding benzo(a)pyrene diol epoxides. These metabolites formation depend on AHH activity.

When metabolizing enzymes are induced by inducers, these enzymes may metabolize benzo(a)pyrene to different products. In presence of benz(a) anthracene induced lymphocytes, correlation between AHH activity and phenol formation has been observed but none between benzo(a)pyrene phenol formation and benzo(a)pyrene -7,8-diol formation, which may be due to induction of enzyme which forms the phenol but not the diol by benz(a) anthracene. Cigarette smoking, likewise, induces specific enzymes, which metabolize benzo(a)pyrene to different metabolites (122).

MUTAGENICITY

PAH: Acenaphthene C.A.S. NO: 83-32-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
--	Test with Salmonella typhimunium TA98, TA100	With Microsome	-	Mutagenic	16

PAH: Anthracene C.A.S. NO: 120-12-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
25-500 μg/plate	Ames Test with TA98	+S9	—	in presence of 1254 ~~On~~ & phenobarbitol induced S9, ~~Am~~ an increase of 250 ~~g~~revertants/plate was observed. A decrease or no change was observed in presence of 2-methyl cholanthrene induced S9 fraction	136
0.3-333.3 mg/plate	Ames assay with TA98, TA100, TA1535, TA1538	±S9	-	Not mutagenic	136
13 ~~km~~ μM/10^6 cells	Human skin fibroblasts	-	-	No detectable DNA damage	136
1-9 ~~mg~~ μg/ml 10-99 ~~mg~~ μg/ml 100-400 ~~mg~~ μg/ml	Human skin epithelial cells	-	-	No statistically significant unscheduled DNA synthesis	136
5% anthracene	Saccharomyces cerevisiae D3	-	-	No significant increase in mitotic recombination	
25, 50, 100, 150 ~~mg/g~~ μg/g	Chinese hamster V-79 cells in host mouse	-	-	No increase in sister chromatic exchange	136
	with horse serum, sodium pyr~~a~~uvate, F-68 pluronic, penicillin and streptomycin			Concentration (Molarity) — Mutants per ~~10⁴~~ 10^4 survivors 7.12×10^{-5} — 1.11 9.6×10^{-5} — 1.30 12.7×10^{-5} — 2.77 Geometric mean number of mutants per plate for 20% or more survival was 61.87 control had 52.63	

PAH: Anthracene C.A.S. NO: 120-12-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
$1x10^{-3}$ $1x10^{-4}$ $1x10^{-5}$ M solubilized in a detergent	Drosophilia Melanogaster X-linked recessive lethal and autosomal recessive assays	oral	-	No significant mutations. No data are given	136
1.6x10-^{5} to 12.7 x10^{-5} M m DMSO	L51784Y mouse lymphoma cells	+ aroclor induced S9 fraction from rat liver	Addition of compound for 3 ~~months~~ hours	Not mutagenic	136
25-500 ng/plate	Ames test with TA98	+S9	-	No increase in revertants/ plate in the absence and presence of S9. Slight increase in revertants per plate in presence of induced S9. ~~In presence of arvelor~~	136
-	Ames test	-	-	Not mutagenic	37
-	Mammalian mutagenicity assay by bonemarrow micronucleus test protcol with B6C3F1/BR Hybrid mice	-	-	Not mutagenic	37
-	Test with salmonella typhimurium TA98, TA100	with microsome	-	Not mutagenic	16
-	Human lymphoblasts ~~Ts~~ TK6 Test	-	-	Not mutagenic	36
-	Salmonella typhimurium	-	-	Not mutagenic	36

PAH: Anthracene C.A.S. NO: 120-12-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Modified Ames test	-	-	Negative mutagenic response	84
compound dissolved in dimethyl sulfoxide. Concentration range with estimated lD50 as the median dose	L51784 mouse lymphoma thymidine ~~ilibase~~ kinase assay (mammalian assay) $Tk^{+/-}$ 3.7.2C cells grown in ~~RPMI~~ RPMI-1640 media	with or without aroclor ~~[illegible]~~ induced or noninduced S9 fraction	Treatment for 72 hours	Not mutagenic with S9 Data are the following: Concentration (Molarity) — Mutants Per ~~104~~ 10^4 survivors 0 — 0.53 1.68×10^{-5} — 0.58 2.25×10^{-5} — 0.58 3.0×10^{-5} — 0.51 4.0×10^{-5} — 0.66 5.34×10^{-5} — 0.76	132

PAH: Anthracene - 9,10 - dione C.A.S. NO: 84-65-1

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
2ng/plate	Salmonella Typhimernium	-	-	Mutation Dose	137
250 mg/ kg	Mice	Intrapentoneal	-	Mutation Dose; DNA damage	137

PAH: Benzo(a) anthracene C.A.S. NO: 56-55-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
5mg/1	Hamster kidney cells	-	-	Mutation Dose; Oncogenic transformation	137
900 ~~1800~~ mg/kg	Hamsters	Intraperitoneal	24 hours	Sister Chromatic exchange test mutation dose	137
900 mg/kg	Hamsters	Oral	24 hours	Sperm morphology test mutation dose	137
100 Umoles	Mammalian lymphocytes	-	-	Mutation dose DNA damage	137
100 Umoles/1	Human Hela cells	-	-	Mutation Dose; DNA damage	137
4mg/1	Mouse fibroblasts	-	-	Mutation Dose; Oncogenic transformation	137
12500 ug ~~mg~~/1	Mouse embroy cells	-	-	Mutation Dose; Oncogenic transformation	137
60Umole/1	Mouse liver cells	-	-	DNA damage	137
1600 mg/kg	Mouse/ Salmonella typhimurium host mediated assay	-	-	Mutation Dose	137
1800 mg/kg	Hamsters	Intraperitoneal	24 hours	Mironucleus test toxic dose	137
109 Umole/1	Hamster lung cells	Metabolic activation	-	Mutation Dose	137
6 mg/1	Hamster embryonal cells	-	7 days	Mutation Dose; Oncogenic transformation	137
1500 mg/kg	Hamsters	Intraperitoneal	24 hours	Mutation Dose, on the basis of cytogenetic analysis	137

PAH: Benzo(a) anthracene C.A.S. NO: 56-55-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
80 ~~mg~~ ug/1	Hamster Kidney cells	-	-	Mutation Dose; Oncogenic transformation	137
100 ~~mg~~ ug/1	Hamster lung cells	-	-	Mutation Dose; Oncogenic transofrmation	137
5 mg/1	Hamster fibroblasts	-	-	DNA Damage; Mutation Dose	137
-	Test with Salmonella Typhimurium; TA ~~100~~ 100	With microsome	-	6his$^+$ revertants/n-mole	1
As benzo (a) anthracene di-hydrodiol	Test with Salmonella Typhimurium, TA100	With Microsome	-	8.5 his$^+$ revertants/ n-mole	1
-	Test with Salmonella typhimurium TA 100	with microsome	-	Mutagenic	16
-	Modified Ames test	-	-	Negative mutagenic response	84
Compound dis-solved in dimethyl sulfoxide concen-trations range with estimated 1D50 as the median dose	Mammalian assay. L5178Y mouse lymphomathymidine kinase assay. TK$^{+/-}$ 3.7.2C cells ~~RPMI~~- grown in ~~RPMI~~- RPMI- -1640 media with horse serum; sodium pyruvate F-68 pluronic, penicillin and streptomycni	With or without aroclor induced or noninduced S9 fraction	Treatment for 72 hours	Mutagenic with S9. The observed data were the following with S9: Concentration (Molarity) — Mutants per 10^4 ~~104~~ survivors 0 — 0.77 $1.35x10^{-5}$ — 0.81 $1.81x10^{-5}$ — 0.84 $2.42x10^{-5}$ — 1.00 $3.22x10^{-5}$ — 1.23 $4.30x10^{-5}$ — 1.47 $5.47x10^{-5}$ — - $7.65x10^{-5}$ — - $10.21x10^{-5}$ — - The cells survival as % of control at the respective concentrations were: 100,96,101,99,89,31,0,0,0.	132

PAH: Benz(a) anthracene C.A.S. NO: 56-55-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE		REF
				The geometric mean number of mutants ~~pa~~ per-plate for 20% or more survival was 111.79. Control had 82.07.		
Concentrations in µM.	L51784 mouse lymphomathymidine kinase. Assay as described above.	+S9		Cell survival (as % of control)	Mean induced frequency per ~~104~~ 10^4 survivors	132
4			-	90	0.125	
5.7			-	88	0.175	
7.7			-	72	0.126	
10			-	60	0.405	
13.6			-	61	0.403	
18			-	28	0.70	
50 ~~mg~~ µg/ plate	Salmonella typhimurium	+metabolic activation	-	Mutation Dose		137
10Umole/ l	Escherichia Coli	-	-	DNA damage		137
50 mg/l	Escherichia Coli		-	Mutation Dose; Phage inhibition		137
5 mmole/ l	Drosophila melanogaster		-	Parental mutation dose. Nondisjunction of thet species.		137
10Umole/ l	Rat liver cells	-	-	Induction of sister chromatic exchange; mutation dose.		137

PAH: Benzo(ghi) perylene C.A.S. NO: 191-24-2

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
	Mice	Subcutaneous injection after dissolving in 0.5 ml tricaprylin	Single injection	Not carcinogenic up to a dose of 1600 mg	3
-	Ames Test	-	-	Mutagenic	37
	Mammalian mutagenicity assay by bone marrow micronucleus test protocol done with B6C3F1/BR mice	-	-	Not mutagenic	37

PAH: Benzo(a) pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella Typhimunium; TA 100	With microsome	-	29 his$^+$ revertants/n mole	1
~~As~~ As benzo (a) pyrene dihydrodiol	Test with Salmonella Typhimurium TA 100	With microsome	-	101 his$^+$ revertants/n mole	1
Cars exhausts particulates extracts; benzo(a) pyrene content Cars operated on different fuels Benzo(a) pyrene concentrations as ~~ng~~ ug/km	Test with Salmonella Typhimurium	With rat S9 microsome	-	Mutagenicity as revertants per Km were the following:	4
11				4.18x10^{-5}	
5.5				3.6x10^{-5}	
1.6				1.06x10^{-5}	
0.1				0.89x10^{-5}	
2.0				0.71x10^{-5}	
1.4				0.625x10^{-5}	
5.5				1.1x10^{-5}	
3.0				0.8‸7x10^{-5}	
0.0				0.2x10^{-5}	
0.4				0.31x10^{-5}	
0.35				0.25x10^{-5}	
Diesel particulate content	With Salmonella Typhimurium TA98 and TA98NR	-S9 (TA98) ~~+ S9~~ (TA98) + S9 -S9 (TA98NR) +S9 (TA98NR)	- - - - - - - -	0 revertants/ng 700 revertants/ng 0 revertants/ng 710 revertants/ng	6

PAH: Benzo(a) pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella Typhimurium TA98	With S9	-	Mutagenicity: 114±5 revertants/~~ng~~ μg	15
-	Ames assay	-	-	++++ activity on a (+ moderate) to ++++ high activity scale.	15
-	Test with mammalian culture	-	-	+++ on a scale + moderate to ++++ very high activity	15
-	Test with Salmonella typhimurium ~~TA98~~ TA98	With microsome	-	Mutagenic	16
0.1 ~~ng~~ μM	-	with microsome	~~0~~ —	Mutagenicity was measured as 23 dead cells per ~~106~~ 10^6 surviving cells	18
Benzo(a) pyrene solubilized in dimethyl sulfoxide. $2x10^{-5}$M $2x10^{-6}$M $2x10^{-7}$M $2x10^{-8}$M $2x10^{-9}$M	Sister chromatid Exchange test with P388D1 cell cultures and human lymphocyte cultures		-	The observed increase in Sister Chromatid Exchange at the doses studied were: 14% at $2x10^{-5}$M 16% at $2x10^{-6}$M 27% at $2x10^{-7}$M 12% at $2x10^{-8}$M 11% at $2x10^{-9}$M	20
-	Test with Salmonella typhimurium				
	TA98	-S9	-	0 revertants/ng	24
	TA98	+S9	-	320 revertants/ng	
	TA100	-S9	-	0 revertants/ng	
	TA100	+S9	-	660 revertants/ng	

PAH: Benzo(a) pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
	Chinese hamster V79 cells from liver, lung, kidney and bladder			The observed activity relative to that of anthracene in the form tisme cells were lung -56; liver-2; kidney -5; bladder-6. Anthracene activity expressed as factor of increase over background per 10^6 activating cells which were nonmutagenic was assigned a value of 1.	27
Extract from a laminar toluene ~~tohrene~~ heptane flame ~~400+%~~ 4 wt. %	Test with Salmonella typhimuriam	PMS activation	-	Mutagenicity was calculated as 1.5×10^{-5} in unspecified units. Total extract mutagenicity was measured as 90×10^{-5}. Expected mutagenicity was 60×10^{-5}	31
-	Test with Salmonella typhimurium	-S9 (TA98)	-	0 revertants/nmole	57
		-S9 (TA100)	-	0 revertants/n mole	
	TA98,TA 100	+S9 (TA98)	-	13± 2 revertants/n mole	
		+S9 (TA100)	-	22±6 revertants/n mole	
-	Chinese hamster ovary cells (CHO) CHO-113-2 and CHO-AT3-2	+S9 or microsomes from rat liver homogenates and cofactors NADPH, NADP, NADH and glucose - 6 - phosphate		The frequencies of mutations ~~undried~~ induced were determined as 2 to 4 days for 8-azaadenine resistance; 6-8 days for 6-thioguanine resistance; 1-3 days for 5 - flouc rodeoxyuridine resistance. The induced mutation frequencies as a function of relative cell survival showed differences in sensitivity which were locus specific.	82

PAH: Benzo(a) pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Chinese hamster ovary cells (CHO) CHO-113-2, CHO-AT3-2 lines	varying concentrations of S9 or microsomes	-	The relative cell survival was dependent on S9 on microsomal concentrations in the ranges studied. Induced mutational frequency was dependent on relative cell survival. Results indicated that benzo(a) pyrrene was maximally metabolized to mutagenic products by microsomes at concentrations of less than or equal to 0.5 mg/ml. Concentrations greater than 0.5 mg/ml lowered induced mutants. Results with S9 have indicated that most efficient conversion of benzo(a) pyrene to mutagenic metabolites. [continued on next page]	82
Concentrations as ~~ng~~ ug per plate 0.062 0.125 0.250 0.500	Arabinose resistant system of salmonella typhimurium. Strains SV-21 and SV-50	+S9 activation		Arabinose resistant mutants per plate at four tested concentrations were: for SV-21: 42, 50, 61 and 64 for SV-50: 719, 1021, 1195 and 1381. The strain SV-21 does not contain the R factor plasmid, which is present in SV-50.	83
-	Modified Ames Test with Salmonella typhimurium strains TA100, TA1538, TA98	Mammalian microsomes 0.4 nmoles/ml	-	Mutagenic	84
-	Ames Test	Metabolic Activation with S9	-	Mutogenicity 115.48 revertants/ nmole	85

PAH: Benzo(a) pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
- Reaction mixture consisted of the compound, +sodium phosphate, D-glucose, histidine, biotin, test culture S9 mix; Davis Mingoli medium after 1 day of incubation	Micro ~~fibre~~ titre fluctuation test with salmonella typhinurium strain TA1538	+~~sq~~ S9, incubated in wells of a 96 wells micro titre tray at 37°C bromothymol blue was added after 4 days of incubation for mutations determination.	-	Wells turning yellow were scored as mutagenic. Such results as wells out of 96 with concentration in ug/ml in paranthesis were: 3(0); 7.5(1); 18(10); 30(25); 22.5(50); 13.5 (100); The cytochrome P450 for the test was maintained at 0.3 nm/ml.	86
				Occur at a S9 concentration of ≥0.1mg/ml followed by a decrease at higher concentration. Relative survival with induced (8-azadenine resistant mutation frequence x 10^{-5}) in parentheses for CHO-AT3-2 cells treated with a compound including benzo(a)pyrene were 0.9(3); 0.77(6.25); 0.61(9.25); 0.48(15.5), Similar data for 6-thioguanine resistant mutation frequency on treatment with 0.04 mM benzo(a)pyrene were: 0.89(3.125); 0.76(6.25); 0.7(9); 0.69(7); 0.54 (12.5); 0.5(15.5). Similar data for Quabain resistance and 5-fluorodeoxyuridine resistance at unspecified benzo(a)pyrene concentrations were respectively: 0.9(0.875); 0.75(1.75); 0.7(3.04); 0.699(2.55); 0.65(2.55); 0.52(3.95); 0.485(4.35) and 0.9(183); 0.85(243); 0.8(357)	82 [Continu from previou Page]

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
0-10 ug/plate; at each level of S9.	Ames Test with strains TA100, TA1537.	+S9 S9 in S9 mix in % were 5, 10 and 30. This is 40 to 330 ul per ml of S9 mix.	-	Mutations as #revertants/ plate as median ranges for varying % of S9 in S9 mix were: 118 - 384 at 5% 110 - 499 at 10% 125 - 607 at 30% for TA100. For TA1537; the data were; 9-36 at 5% 12-47 at 10% 10-74 at 30%	87
Compound dissolved in dimethyl sulfoxide. Estimated ID50 as the median dose of the dose range.	L5178Y mouse lymphoma thymidine kinase assay. (mammalian assay). TK+/-3.72C cells grown in RPMI-1640 media with horse serum sodium pyruvate, F-68 pluvtonic, penicillin and streptomycin.	With or without aroctor induced or noninduced S9 fraction.	Treatment for 72 hours.	Mutagenic with S9 mutagenicity expressed as mutants per 10^4 survivors and the respective concentrations were the following with S9. Concentration Molarity — Mutants per 10^4 Survivors 0 — 0.68 0.53×10^{-5} — 1.36 0.7×10^{-5} — 1.79 0.94×10^{-5} — 1.47 1.25×10^{-5} — 1.87 1.67×10^{-5} — 2.60 2.23×10^{-5} — 2.49 2.97×10^{-5} — 2.65 3.96×10^{-5} — 3.97 The geometric mean number of mutants per plate for 20% or more of cell survival were 119.32. Control had 72.84	132

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Microtitre test with Salmonella typhimurium TA1538.	Varying S9 levels; variations in S9 induction.		Mutagenicity varied with variations in S9 level. The optimum level of S9 mixture was determined as 75 ul S9/ml of reaction mixture. Data of increased mutations (test-control) with variations in S9 levels in parenthesis were the following: 0(3); 3.5(25); 1.75(50); 12.5(75); 32(100); for atroctor induced S9. 2.5 (3.1); 2.6(25); 2.4(50); 10(75); 23(100) for phenobarbitone/B-naphthoflavone induced S9.	86
-	Microtitre test with Salmonella typhimurium TA1538.	Variations in S9 induction. Aroclor [A] or phenobarbitone/B- naphthoflavone [PB] induction.	-	Results with mode of induction in parentheses are the following: Concentration of S9 (ug/ml) — Increased Mutation 5(A) o 5(PB) 2.5 10(A) 0 10(PB) 12 13.5(A) 9 13.5(PB) 45 17.5(A) 56 17.5(PB) 50 20(A) 72.5 20(PB) 66.0 25(A) 84 25(PB) 80	

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Concentration in uM 0,4,8, 12.	Test with S49 mouse lymphoma cells; Plate assay in medium.	with Metabolizing system/ rat liver S9 fraction.		The test system determines mutation frequencies with respect to dexamethasone resistance, 6-thioguanine resistance and ~~ar~~ouabain resistance. The data for S491 dixamethasone resistance systems were the following. Dexamethasone resistant mutants per 10^6 cells at the respective concentrations with ranges in parentheses were: 80(50-120); 400(360-440); 645(500-870); 520(360-660) % cells survival at the respective concentrations were: 100,90,56, 35. A cells survival of 40% is determined as the lowest accepted level for mutations determination. The maximum mutation frequency induced with respect to 6-thioguanine resistance was determined as 870 per 10^6 platable cells. The compound is mutagenic in the test system.	1
Doses in ug/ plate 0.1 0.35 1.0 3.0 10.0 Microsomes; 0.37mg rat intestine. 0.80mg rat liver	Salmonella microsome assay. TA98 and TA100 Plate assay by Ames Test.	In presence of metabolizing enzymes derived from rat small intestine villo~~a~~us tip cells. Induction with phenobarbitone by drinking water and β-naphthoflavone in corn oil by gavage. In presence of rat liver S9 fraction.		Mutations as ~~R~~revertants per plate at the respective concentrations in presence of rat intestine microsomes were: 50-72; 75-120; 85-138; 100-205; and 150-181.25. Mutations as revertants per plate in presence of rat liver microsomes were at the respective concentrations; 170; 162.5; 175-240; 825-920; 588-640. Intestinal preparations activated the compound.	116

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
				but the same preparations prepared by a glass scraping method did not detect significant mutagenicity. In presence of S9, mutagenicity increased to a peak value and then declined. In presence of intestinal microsomes, response increased linearly. Rat intestinal microsome preparations have lower activity than rat liver microsomes. Likely metabolites in presence of rat intestinal microsomes are B(alP-7,8-diol, 9-10-epoxide and B(a)P-4,5-oxide preferential formation at low concentrations.	
	HeLa DNA Synthesis inhibition test. HeLa Cells	Incubation of the compound with S9 fraction from aroclor induced rat liver microsomes in medium containing labelled thymidine	–	The compound was considered positive if the rate of DNA synthesis decreased monotonically to at least 60% of the control rate at 30 or 90 minutes after removal of the agent. Benzo(a)pyrene was found to be +ve in presence of S9 at an effective dose of 7.0×10^{-6}M.	115

PAH: Biphenyl C.A.S. NO: 92-52-4

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Modified Ames Test.		-	Negative mutagenic response	84

PAH: Carbazile

C.A.S. NO: 86-74-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella typhimurium TA100.	With microsome.	-	Not mutagenic.	16

PAH: Chrysene C.A.S. NO: 218-01-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
43ug/ tube. Irradiated and nonirradiated chrysenes	Escherichia coli Pol A Strain test.	In vitro	-	Nonirradiated chrysene was not mutagenic. Irradiated chrysene was mutagenic. Chrysene may be phototransformed to a direct acting mutagen.	136
450 mg/kg.	Chinese hamster bone marrow SCE Test.	-	-	Chrysene treated hamsters had significant sister chromatid exchanges over the control.	13

PAH: Chrysene C.A.S. NO: 218-01-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella typhimurium TA100.	With microsome.	-	Mutagenic	16
Up to 1.5 uM/ Plate in DMSO	Ames Assay with TA98, TA100.	+ ~~S9~~ induced S9.	-	Mutagenic in TA100. With 196 revertants per plate at a dosage of 0.005 u moles chrysene per plate. The number of spontaneous revertants was substrated. It was not mutagenic with S9 in TA98.	136
6-750 ug/ plate	Ames assay with TA98.	+ induced and noninduced S9.		Maximum mutagenic effect at 500 ug per plate; with increase in revertants per plate of 250 in presence of phenobarbital induced S9. An increase of 500 revertants/plate was observed in presence of aroclor 1254 induced S9.	136
45uM/ Plate	H~~U~~GPRT test with Salmonella typhimurium strain TM677.	In vitro + aroclor induced rat liver homogenate.	-	The tested concentration was the lowest concentration which induced significant mutations. Mutagenicity relative to benzo(a)-pyrene was 0.20.	136
0 ~~on~~ or 250 ug/ plate	Ames assay with Salmonella typhimurium TA1535 TA1538.	+, - uninduced S9.	-	Not mutagenic. The results at 0 and 250 ug/plate were respectively 22 and 26 mutants per plate without activation in TA1535; 21 and 24 with activation in TA1535; 19 and 20 mutants/plate in TA1538 with activation.	136

PAH: Chrysene C.A.S. NO: 218-01-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
330 mg/ kg. in DMSO.	Mice host mediated assay with Salmonella typhimurium TA1535, TA1538.	Oral	Single dose.	Not mutagenic. No significant increase in mutation frequency in TA1538 and TA1535.	136
100ul of 4.3mg per ml solution 430ug/ plate in DMSO. Both chrysene irradiated with 430nm light and nonirradiated were used.	Ames assay with TA98	- S9	-	Increased back mutations in irradiated chrysene cultures. 71 revertants per plate 6 revertants per plate with nonirradiated chrysene. Irradiation of chrysene resulted in the formation of a direct acting mutagen.	136
1000ug ~~1000ug~~ or 4.38 umole per plate	Ames assay with TA1535, TA1536, TA1537, TA1538.	I aroclor 1254 induced S9	—	Not mutagenic	136

PAH: Cyclopenteno(c,d)pyrene C.A.S. NO: 27208-37-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Compound dissolved in dimethyl sulfoxide and tested in 3% horse serum Concentration range: 0.75 to 30 ug/ml.	Mammalian system test L5178Y mouse lymphoma cells.	With and without aroclor 1254 induced rat liver S9.		It was not mutagenic without activation in the concentration range tested. With S9 activation, the mutation frequency x10^6 were the following. The concentrations in ug/ml are in parentheses: 120(1.2); 172(1.3); 138 (1.4); 139(1.5); 188(1.6).	103
	Mouse cells	- S9 + S9	-	Not mutagenic. Mutagenic with dose related responses.	41
Dissolved in dimethyl sulfoxide and in presence of 3% horse serum					
0 ug/ml		-S9		137 mutants/10^6 survivors	
1.11 ug/ml		-S9		200 mutants/10^6 survivors	
1.13 ug/ml		+S9		1325 mutants/10^6 survivors	
1.56 ug/ml		+S9		2000 mutants/10^6 survivors.	

PAH: Cyclopenteno(c,d)pyrene C.A.S. NO: 27208-37-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Extract from a laminar toluene ~~t[illegible]e~~-heptane flame, 14wt%	Test with Salmonella typhimurium	PMS activation.	-	Mutagenicity in unspecified units. $35x10^{-5}$. Total extract mutagenicity: $90x10^{-5}$; total extract mutagenicity expected: $60x10^{-5}$.	31
-	Test with Salmonella typhimurium strain TM677.	+ PMS	-	Mutation to 8-azaguanine resistance was determined as 30 (mutant fraction $x10^5$) @ 20uM and 145 (mutant fractions x 10^5) @ 40 uM. Mutation was +13 in presence of PMS and -44 in absence of PMS; not mutagenic in the absence of PMS.	317
-	Ames assay with activation and bacterial assay.		-	Mild mutagenic in Ames assay and very mutagenic in bacterial assay.	103

PAH: Dibenz(a,h)anthracene C.A.S. NO: 53-70-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
450mg/kg. two doses in 24 hours.	Hamsters bone marrow.	Injections.		Sister chromatid exchanges per metaphases were 4.9 ±0.07 compared to a control value of 3.9±0.9. Structural chromosomal aberrations were negative.	136
10ug/plate	Salmonella typhimurium microsomal mutagenicity assay.	-	-	Mutation dose.	137
2500 ug/1.	-	-	-	Hamster embryo mutation dose; oncogenic trasnformation.	137
900 mg/kg.	Hamsters	Intraperitoneal	-	Mutation dose in sister chromatid exchange test.	137

PAH: 1,3-Dinitropyrene C.A.S. NO: 75321-20-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Dinitropyrene	Chinese hamster lung cells.	Without S9.	-	Mutagenic using diphtheria resistant toxin as marker.	8
Dinitropyrenes	Test with Salmonella typhimurium TA98.	Without S9.	-	Mutagenicity: 67000 revertants/ug. This represented 20.6 to 49.3% of total diesel particulates extract mutagenicity.	10
0.1uM	-	With microsome	-	Mutagenicity was measured as 74 dead cells per 10^6 surviving cells.	18
-	Test with Salmonella typhimurium				
	TA98	- S9	-	561000 revertants/ug	24
	TA98	+ S9	-	0 revertants/ug	
	TA100	- S9	-	126000 revertants/ug	
	TA100	+ S9	-	0 revertants/ug.	
1981 diesel passenger car exhausts particles extracts. 0.3±0.2 ppm; approximate sample concentration	Ames assay with TA98.	- S9	-	Mutagenicity was recorded as 1250 revertants/fraction. (Spontaneous revertants were deducted from the result).	

PAH: 1,6-Dinitropyrene C.A.S. NO: 42397-65-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Dinitropyrene	Chinese hamster lung cells.	Without S9.	-	Mutagenic using diphtheria resistant toxin as marker.	8
Dinitropyrenes	Test with Salmonella typhimurium TA98.	Without S9.	-	Mutagenicity: 67000 revertants/ug. This represented 20.6 to 49.3% of total diesel particulates extract mutagenicity.	10
0.1 uM	-	With microsome.	-	Mutagenicity was measured as 210 dead cells per 10^6 surviving cells.	18
-	Test with Salmonella typhimurium				
	TA98	- S9	-	230000 revertants/ug	24
	TA98	+ S9	-	0 revertants/ug	
	TA100	- S9	-	35000 revertants/ug	
	TA100	+ S9	-	0 revertants/ug.	
1981 diesel passenger car exhausts particles extracts. 0.4±0.2 ppm, approximate sample concentration	Ames assay with TA98.	- S9	-	Mutagenicity was recorded as 2000 revertants/fraction. (Spontaneous revertants were deducted from the result).	65

PAH: 1,8-Dinitropyrene C.A.S. NO: 42397-65-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Dinitro-pyrene	Chinese hamster lung cells.	Without S9.	-	Mutagenic using diphtheria resistant toxin as marker.	8
Dinitro-pyrenes	Test with Salmonella typhimurium TA98.	Without S9.	-	Mutagenicity: 67000 revertants/ug. This represented 20.6 to 49.3% of total diesel particulates extract mutagenicity.	10
0.1 uM	-	With microsome.	-	Mutagenicity was measured as 152 dead cells per 10^6 surviving cells.	18
1981 - diesel passenger car exhausts particles extracts 0.5 ± 0.3 to 0.7 ± 0.2 (appr. conc.)	Ames assay with ~~Test with~~ Salmonella typhimurium TA98 ~~TA98~~ ~~TA100~~ ~~TA100~~.	- S9 ~~+ S9~~ ~~- S9~~ ~~+ S9~~.	- - - -	Mutagenicity was recorded as 625 revertants/fraction (spontaneous revertants were deducted from the result).	65
—	Test with Salmonella typhimurium strains TA98 TA1537 TA1538 TA1535.	- S9 - S9 - S9 - S9.	- - - -	92000 revertants/n.mole 36000 revertants/n.mole 32000 revertants/n.mole -	
—	Test with Salmonella typhimurium TA98 TA98 TA100 TA100	- S9 + S9 - S9 + S9	— — — —	940,000 revertants/ug 0 revertants/ug 115000 revertants/ug 0 revertants/ug	24

PAH: Fluoranthene C.A.S. NO: 206-44-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella typhimurium TA98.	With microsome	-	Mutagenic	16
Extract from a laminar toluene-heptane flame. 4 wt%	Test with Salmonella typhimurium-m.	PMS activation (post mitochondrial supernatant enzyme).	-	Mutagenicity was measured as 10×10^{-5} in unspecified units. Total extract mutagenicity was measured as 90×10^{-5}; expected mutagenicity was 60×10^{-5}.	31
100 mg/liter	Salmonella typhimurium mutation assay.	Metabolic activation	72 hours.	Mutation Dose	137

PAH: Indeno(1,2,3-cd)pyrene C.A.S. NO: 193-39-5

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
3 ug/ plate	Microsomal Salmonella typhimurium mutagenicity assay.	-	48 hours.	Mutation dose.	137

PAH: 1-Methylnaphthalene C.A.S. NO: 90-12-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
6 n. moles per liter	Salmonella typhimurium.	Metabolic activation.	2 hours.	Mutation Dose	137

PAH: Naphthalene C.A.S. NO: 091-20-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella typhimurium TA98, TA100.	With microsome.	-	Not mutagenic.	16

PAH: 9-Nitroanthracene C.A.S. NO: 602-60-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Diesel particulates component.	Test with Salmonella Typhimurium TA98 and TA98NR (nitroreductase deficient strain).	- S9 (TA98) + S9 (TA98) - S9 (TA98NR) + S9 (TA98NR)	- - - -	Mutagenicity: 0.3 revertants/ug 0.32 revertants/ug. 0.14 revertants/ug 0.13 revertants/ug.	
-	Test with Salmonella Typhimurium TA98.	Without S9.	-	Mutagenicity: 0.5 revertants/ug. This represented less than 0.1% of total diesel particulates extract mutagenicity.	10

PAH: 6-Nitrobenzo(a)pyrene C.A.S. NO: 63041-90-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Diesel particulate content.	Test with Salmonella Typhimurium TA98 and TA98NR (nitroreductase deficient strain).	- S9 (TA98) + S9 (TA98) - S9 (TA98NR) + S9 (TA98NR)	- - - -	Mutagenicity: 0 revertants/ug 1500 revertants/ug. 0 revertants/ug 1800 revertants/ug.	6
Nitrobenzo-(a)pyrenes.	Test with Salmonella Typhimurium TA98.	Without S9.	-	Mutagenicity: 180 revertants/ug. This represented 0.1-0.3% of total diesel particulates extract mutagenicity.	

PAH: 3-Nitrofluoranthene C.A.S. NO: 892-21-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella Typhimurium				
	TA98	+ S9	-	179 revertants/ug	24
	TA98	- S9	-	55900 revertants/ug	
	TA100	+ S9	-	174 revertants/ug	
	TA100	- S9	-	23600 revertants/ug.	
1981 diesel passenger car exhausts particles extracts. 2±2ppm, approximate sample concentration.	Ames assay with TA98	- S9	-	Mutagenicity corresponding to nitrofluoranthene was recorded as 4500 revertants/fraction. Spontaneous revertants were deducted from the result.	65

PAH: 8-Nitrofluoranthene C.A.S. NO: 13177-32-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1981 diesel passenger car exhausts particles extracts 3±2ppm; approximate sample concentrate	Ames assay with TA98.	- S9.		Mutagenicity corresponding to nitrofluoranthene was recorded as 4500 revertants/fraction. Spontaneous revertants were deducted from the result.	65

PAH: 9-Nitrophenanthrene C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
9-Nitrophenanthrene	Test with Salmonella Typhimurium				
	TA98	- S9	-	1300 revertants/ug.	24
	TA98	+ S9	-	197 revertants/ug	
	TA100	- S9	-	4400 revertants/ug	
	TA100	+ S9.	-	97 revertants/ug.	

PAH: b-Nitrophenanthrene C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
9-Nitrophenanthrene	Test with Salmonella Typhimurium				
	TA98	- S9	-	1300 revertants/ug	
	TA98	+ S9	-	197 revertants/ug	
	TA100	- S9	-	4400 revertants/ug	
	TA100.	+ S9.	-	97 revertants/ug.	

PAH: C-Nitrophenanthrene C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
9-Nitrophenthrene	Test with Salmonella Typhimurium				
	TA98	- S9	-	1300 revertants/ug	
	TA98	+ S9	-	197 revertants/ug	
	TA100	- S9	-	4400 revertants/ug	
	TA100	+ S9	-	97 revertants/ug.	

PAH: 1-Nitropyrene C.A.S. NO: 5522-43-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Untreated carbon black six samples.	Test with Salmonella Typhimurium TA98 and TA100.	+ S9.		Mutagenicities in (revertants/gm)x 10^{-5} were: TA98 - 3.2, 20.2, 30.4, 1.0, 1.0, 1.0. TA100 - 6.6, 32.0, 37.0, 1.0, 1.0, 1.0.	
Reference carbon black NP concentrations in ppm were: 0.351, 0.4, 0.425, 0.4, and 0.457.	Test with Salmonella Typhimurium TA98.	- S9		Calculated mutagenicities at the respective doses in (revertants/10gms) $x10^{-6}$ were: 1.8, 2.2, 2.5, 1.9, 2.5, The actual data were: 2.12, 2.18, 2.13, 1.52, 1.08.	70

PAH: 1-Nitropyrene C.A.S. NO: 5522-43-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1981 diesel passenger car exhausts particle extracts. 75-95 ±10 ppm approximate sample concentration.	Ames assay with TA98.	- S9	-	Mutagenicity was recorded as 4250 revertants/fraction (spontaneous revertants were deducted from the result).	65
Carbon black; chlorobenzene extract & solvent exchange with dimethyl sulfoxides NP ng/ plate 0.19, 0.38, 0.75, 1.5, and 3.0.	Test with Salmonella Typhimurium TA98 and TA1537.	- S9	-	Mutagenicity in TA98 without solvent exchange at the respective doses in revertants/plate were 90, 159, 312, 580 and 1193. With solvent exchange the results were; 113, 215, 394, 658 and 13586. Similar results in TA1537 without solvent exchange were respectively 42, 87, 159, 297, 683, and 38, 67, 123, 253, 560.	70

PAH: 1-Nitropyrene C.A.S. NO: 5522-43-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1981 treated carbon black Nitropyrene contents in ppm. 0.091, 0.097, <0.054, 0.237, 0.318, 0.063, 0.065				Mutagenicities calculated as (revertants/gm)x10^{-5} at the respective doses were: 4.0, 3.9, 1.7, 11.0, 16.0, 2.6 and 2.68. The corresponding actual mutagenicities were: 5.1, 3.6, 0.8-1.1, 13.0, 21.0, 2.2 and 1.8.	70
Diesel particulate content.	Test with Salmonella Typhimurium TA98 and TA98NR. (Nitroreductase deficient strain).	+ S9 (TA98) - S9 (TA98) + S9 (TA98NR) - S9 (TA98NR)	- - - -	Mutagenicity: 6100 revertants/ug. 3500 revertants/ug. 3700 revertants/ug 380 revertants/ug.	6
-	Chinese hamster lung cells	Without S9.	-	Not mutagenic when tested using diphtheria resistant toxin as marker.	8
Nitropyrene	Test with Salmonella Typhimurium TA98.	Without S9.	-	Mutagenicity: 2000 revertants/ug. This represented 24-30.8% of total diesel particulates extract mutagenicity.	
1 uM		With microsome.	-	Mutagenicity was measured as less than 2.0 dead cells per 10^6 surviving cells.	18

PAH: 1-Nitropyrene C.A.S. NO: 5522-43-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Test with Salmonella Typhimurium				
	TA98	- S9	-	2000 revertants/ug	24
	TA98	+ S9	-	71 revertants/ug	
	TA100	+ S9	-	169 revertants/ug	
	TA100	- S9	-	390 revertants/ug.	
Diesel particulate extract with 55,175 and 2000 ppm of 1-Nitropyrene.	Test with TA98.		-	The compound caused 10%, 10% and 25% respectively of the total extract mutagenicity.	65
Total PAH extract of ambient particulate matter.	Ames Test				
385ng/m^3	TA98	- S9	-	41-45 revertants/m^3	
385ng/m^3	TA98	+ S9	-	34-180 revertants/m^3	
79ng/m^3	TA98	- S9	-	9-10 revertants/m^3	
79ng/m^3	TA98	+ S9	-	12-28 revertants/m^3	
65ng/m^3	TA98	- S9	-	8-37 revertants/m^3	
65ng/m^3	TA98	+ S9	-	9-49 revertants/m^3	

PAH: PAH

C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Fractionated PAH extract of ambient particulates Nonpolar.	Ames Test				
	TA98	- S9	-	<0.8 revertants/m^3	
	TA98	+ S9	-	0.2-2.1 revertants/m^3	
Nitro-substituted PAH	TA98	- S9	-	0.3-1.9 revertants/m^3	
	TA98	+ S9	-	0.6-4.7 revertants/m^3	
N-heterocyclic PAH and acid.	TA98	- S9	-	2.5-11.2 revertants/m^3	
	TA98	+ S9	-	2.8-16.8 revertants/m^3	
Unfractionated sample.	TA98	- S9	-	3.1-14 revertants/m^3	
	TA98	+ S9	-	2.4-16 revertants/m^3	
Total PAH extract of ambient particulate matter	Ames Test				22
355ng/m^3	TA 98	- S9	-	41-45 revertants/m^3	
355ng/m^3	TA 98	+ S9	-	34-180 revertants/m^3	
79ng/m^3	TA 98	- S9	-	9-10 revertants/m^3	
79ng/m^3	TA 98	+ S9	-	12-28 revertants/m^3	
65ng/m^3	TA 98	- S9	-	8-37 revertants/m^3	
65ng/m^3	TA 98	+ S9	-	9-49 revertants/m^3	

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Combustion products from heptane/toluene flame compounds identified include, cyclopenta (c,d) pyrene, fluoranthene, alkylphenanthenes, benzo (a) pyrene and other PAHs.	Tested for specific mutagenicity as mutation to 8-azaguanine resistance in Salmonella Typhimurium.	-	-	The observed mutations corresponded to a total PAH concentration of 90×10^{-5} (units unspecified). Mutation corresponding to a concentration of 60×10^{-5} was expected. The enhanced mutagenicity is attributed to the indicated PAHs in the dose column.	31

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Total PAH content of cars exhaust particles extracts. Cars operated on different fuels. Concentrations as ug/km.	Test with Salmonella Typhimurium	With microsome.		Mutagenicity as revertants per Km were the following:	4
950				5.25×10^{-5}	
165				3.8×10^{-5}	
65				3.5×10^{-5}	
0.25				0.9×10^{-5}	
2.5				0.8×10^{-5}	
1.5				0.7×10^{-5}	
160				1.2×10^{-5}	
125				1.125×10^{-5}	
12.5				0.25×10^{-5}	
26				0.33×10^{-5}	
25				0.28×10^{-5}	
Total PAH extract of ambient particulates.	Ames Test with TA98, TA98NR (Nitroreductase deficient) TA100, TA100NR.	- S9 (TA98)	-	13-21 revertants/m^3	
		+ S9 (TA98)	-	7-14 revertants/m^3	
		- S9 (TA98NR)	-	6-14 revertants/m^3	
		- S9 (TA100)	-	16-34 revertants/m^3	
		+ S9 (TA100)	-	11-21 revertants/m^3	
		- S9 (TA100NR)	-	7-19 revertants/m^3	
	With TA98; 1,8-Dinitropyrene	-	-	3-7 revertants/m^3	

PAH: PAH

C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Coal fly ash samples.	Ames Test using Salmonella Typhimurium strains TA98, TA1535, TA1537, TA1538.	+ S9 (TA1535 and TA1537).	-	No activity. Small increase in activity in presence of S9. Mutagenicity was dependent on solvent used for extraction. Serum extracts were more mutagenic than cyclohexane extracts which were ten times more mutagenic than phosphate buffered saline extracts. Increased mutagenicity on addition of ethylene diamine tetracetic acid to serum extracts; probably as a consequence of formation of complexes.	32
Power plant fly ash dimethyl sulfoxide extracts.	Ames Test with TA1538.	- S9	-	Observed mutagenicity were; 6, 32, 75 and 100 His^+ revertants/mg of fly ash. These were twice the activities of serum extracts and four times the activities of cyclohexane extracts. Mutagenic responses were also observed with TA98. Compounds present in the extract are likely to include pAH, nitrosubstituted PAHs, aromatic nitrogen heterocyclic compounds. Treatment of fly ash with an aqueous base causes a reduction in mutagenicity.	32

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Diesel soot methylene chloride extract.	Human lymphoblasts TK6 assay; Trifluorothymidine resistant.	In presence of rat liver PMS.		Mutations in human lymphoblasts:	36
0				$1.5x10^6$	
50ug/ml				$2.5x10^6$	
100ug/ml				$5.5x10^6$	
200ug/ml				$7.6x10^6$ The surviving fractions were 0.54 at 50ug/ml; 0.46 at 112ug/ml; 0.225 at 193ug/ml. The significant concentration, which causes $5.6x10^6$ mutants was as 100ug/ml.	
Diesel soot methylene chloride extract.	Salmonella Typhimurium.	In presence of PMS.	-	The significant concentration was recorded as 10ug/ml of hexane/toluene subfraction of methylene chloride which caused 8-azaguanine resistant mutants of $1.7x10^5$.	
Wood combustion emissions extracts-central heating furnace.	Ames Salmonella microsome plate incorporation test TA98, TA98NR, TA98/1,8-dinitropyrene, TA100, TA100NR strains.	- S9.	-	Mutagenicity as revertants per kg dry fuel for two samples were: TA98 - 1200, 1300 TA98NR - 740, 1000 TA98 and 1,8-Dinitropyrene) 500 and 700 TA100 - 2200, 1800 TA100NR - 1500, 1300.	74

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Extracts from typewriter ribbons; typewritten papers; printer black ink dissolved in water or dimethyl sulfoxide; carbon paper.	Salmonella typhimurium microsome assay TA98, TA98NR.	In presence and absence of S9.		Typewriter ribbon extracts were mutagenic, highest mutagenicity was observed in the absence of metabolic activation in TA98. Reduced mutagenicity was observed in TA98NR compared with TA98. Reductions varied from 25 to 70%. Variations in number of revertants with variations in typewriter ribbon cartridges were observed. Nitrogroups containing compounds are probably present in extracts. Typewriter paper extracts were mutagenic. Mutagenicity depended on thickness of paper and mode of extraction. Carbon paper extracts and printing ink showed variable mutagenicity including nondetectable. Carbon paper extracts had highest mutagenicity in presence of S9 in TA98. Some ribbons and carbon paper extracts were toxic to bacteria. Direct mutagenic effect of ribbon extracts may be due to the presence of arene dicarboxylic anhydrides, arene lactones, arene oxides, nitro or nitrosoarenes. Mutagenicity in presence of S9 may be due to the presence of cyclopenta(c,d)pyrene and benzo(a)pyrene.	113

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Coal combustion, fluidized bed fly ash extracts.	Test with Salmonella Typhimurium strains TA98, TA98NR, TA98/1,8-DNP$_6$ which is less sensitive to nitroarenes.	In presence and absence of rat liver S9.		The extract was mutagenic in the strains tested. Addition of S9 decreased mutagenicity indicating direct acting mutagenicity. mutagenicities in revertants/ug were: 50±2 revertants/ug in TA98; 29±2 revertants/ug in TA98NR and 7.2±o.5 revertants/ug in TA98/1,8-DNP$_6$.	121
Coal combustion fluidized bed fly ash extracts.	Chinese hamster ovary cells (CHO) clone K$_1$-BH4. Mutation test at the hypoxanthine-guanine phospho ribosyl transferase gene locus . and at the Na$^+$-k$^+$-AT Pase gene locus .	In presence of rat liver S9 fraction.		The extract was not mutagenic in CHO cells at the HGPRT gene 1 and at Na$^+$-k$^+$-AT.P in the absence of S9, indicating no direct acting mutagenicity. Mutagenicity was observed on addition of S9. The results in presence of S9 were: 7 mutants per 10^6 surviving cells per ug per ml at the Na$^+$-k$^+$-ATP gene loci and 45 mutants per 10^6 survivors per ug per ml at the HGPRT gene loci. Direct acting mutagenicity in Salmonella Typhimurium may be due to transformation of nitro moiety to mutagenic intermediates by bacterial enzymes, bacterial reductases. In CHO cells, the activity is likely due to PAHs requiring S9 or due to nitro PAHs which undergo ring oxidation compared to NO$_2$ reduction ~~on~~ or both initially. Mammalian cells which lack nitroreductases, which are present in bacteria, do not exhibit high responses to nitro PAHs.	

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Wood combustion particles on condensed aerosols.	Ames Salmonella Typhimurium Test, TA98.	TA98 (-S9) TA98 (+S9) TA98 (-S9) TA98 (+S9) TA98 (+S9)	- - - - -	Mutagenicity as revertants/ug organic compounds were the following: Pine: 0.3 Pine: 1.3 Oak: 0.12 Oak: 0.8.	80
Wood or fuel oil emissions as particles on condensable aerosols.	Salmonella Typhimurium Ames Test with TA98.	TA98 + S9.	-	Mutagenicity as revertants x10^5 per kg fuel were: Pine: 158 Oak: 29 Fuel Oil No. 1: 0.4 Fuel Oil No. 2: 3.6.	
Emissions from wood stoves, residential furnace; diesel vehicles and cigarette smoke.	Ames Salmonella Typhimurium TA 98 test.	+ S9.	-	Relative mutagenicities were: Pine: 0.7 Oak: 0.5 Fuel Oil #1: 1.0 Fuel Oil #2: 2.6 Diesel; Oldsmobile: 0.7 Diesel, VW: 3.0 Gasoline, vehicle: 4.0 Cigarette smoke: 0.6	

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Organic contents of airborne particulates dissolved in dimethyl sulfoxide.	Salmonella plate assay with TA98 and TA98NR.	- S9		Mutagenicity of organic matter varied with variations in collection sites and seasons. The samples were more mutagenic to TA98 than to TA98NR indicating presence of nitroaromatic compounds or nitroheterocyclic compounds. The organic concentrations range (ug/m^3)/ corresponding benzo(a) pyrene concentrations (ng/m^3) range and mutagenicity in TA98 in revertants/m^3 at varying sites were respectively, 4.66-9.12, 0.49-2.32, 10.0-62.4. 6.92-14.25, 4.10-10.6, 6.5-10.2, 2.23-5.77, 0.39-0.95, 0.7-177.1, 4.15-8.26, 0.47-1.4, 5.3-33.5, 15.5-17.23, 6.95-11.9, 9.6-13.4. At an organic concentration of 300 ug/plate, from samples collected during all four quarters; the mutagenicity range in revertants/plate in TA98 was 109-1227. Similar range in TA98NR was 61-951.	127
				At an organic concentration of 150ug/plate, mutagenicity in TA98 was 1048 revertants/plate and 426 revertants/plate in TA98 NR. At an organic concentration of 75ug/plate; mutagenicity in TA98 was 2481 revertants/plate and 1665 revertants/plate in TA98 NR.	127

PAH: Perylene C.A.S. NO: 198-55-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Diesel particulate content.	With Salmonella Typhimurium TA 98 and TA98NR (nitroreductase deficient strain).	- S9 (TA98) + S9 (TA98) - S9 (TA98NR) + S9 (TA98NR)	- - - -	Mutagenicity: 0 revertants/ug 0 revertants/ug 0 revertants/ug 0 revertants/ug.	6

PAH: Phenanthrene C.A.S. NO: 85-01-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
~~100ul of 4.3mg/ml solution. 430ug/plate in DMSO. Both chrysene irradiated with 430 nm light and non irradiated were used.~~	~~Ames assay with TA98.~~	~~- S9~~		~~Increased back mutations in irradiated chrysene cultures. 71 revertants per plate. 6 revertants per plate with nonirradiated chrysene. Irradiation of chrysene resulted in the formation of a direct acting mutagen.~~	~~136~~
~~1000ug or 4.38 u.mole per plate~~	~~Ames assay with TA1535, TA1536, TA1537, TA1538.~~	~~± aroclor 1254 induced S9.~~	-	~~Not mutagenic~~	~~136~~
40mg/litre	Hamster lung cells.	-	27 hrs.	Mutation dose by cytogenetic analysis.	137
900mg/~~k~~ kg.	Hamsters	Intraperitoneal	24 hours	Sister chromatid exchange test mutation dose.	137

PAH: Phenanthrene C.A.S. NO: 85-01-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
100ug/ plate	Ames assay TA98, TA100, TA1537.	+ induced rat liver microsomes.	-	The compound is weakly mutagenic. It was mutagenic with TA100 in presence of aroclor 1254 induced rat liver microsomes. It was not mutagenic with TA1537 in presence or absence of arcolor 1254 induced rat or mice liver microsomes. In presence of 1,1,1-trichloropropene oxide, phenanthrene was converted to metabolites which were mutagenic to TA1537, in presence of induced microsomes. The compound was not mutagenic in TA98.	136
0.03, 0.3, 3 u.mole/ plate	Ames assay TA98, TA100.	±induced S9 mix.	-	Not mutagenic.	
100mg/ kg.	Hamsters.	Intraperitoneal.	-	Slight increase in sister chromatid exchange.	136
10^{-5}, 10^{-4}, 10^{-3} M.	Chinese hamsters cells.	-	-	Sister chromatid exchange incidences were respectively 9.64±0.63; 9.62±0.67; 10.56±0.87. These did not satisfy the SCE induction criterion.	136
20 to 200uM	Esche~~s~~richia Coli ~~Q13~~ ~~Q73~~ Q13	In vitro.	-	Increased DNA binding at 200uM dose level. On testing with ~~hyperzyme~~ lypozyme, DNA binding was increased by 0.4% and 0.9% at 20 and 200uM doses respectively. Addition liver extract did not increase DNA binding. The test is reported as negative.	136

PAH: Phenanthrene C.A.S. NO: 85-01-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Ames test	-	-	Not mutagenic.	37
-	Mammalian mutagenicity assay by a bone marrow micronucleus test protocol with B6C3F1/BR hybrid mice.	-	-	Not mutagenic.	37
-	Test with Salmonella Typhimurium TA98.	With microsome.	-	Mutagenic.	16
-	Human lymphoblasts TK6 test.	-	-	Significant mutagenicity.	36
-	0uM 50uM 100uM 200uM	-	-	Mutations were recorded as: 4x10^{-6} 5x10^{-6} 5x10^{-6} 11x10^{-6} The surviving fractions were recorded as 1.0, 0.81, 0.74, 0.59.	
-	Modified Ames Test.	-	-	Negative mutagenic response.	84

PAH: Pyrene C.A.S. NO: 129-00-0

<table>
<tr><th>DOSE</th><th>SPECIES</th><th>ROUTE</th><th>PERIOD</th><th>EFFECT/RESPONSE</th><th>REF</th></tr>
<tr><td>-</td><td>Ames test</td><td>-</td><td>-</td><td>Not mutagenic</td><td>37</td></tr>
<tr><td>-</td><td>Mammalian mutagenicity assay by a bone marrow micronucleus test protocol with B6C3F/BR mice.</td><td>-</td><td>-</td><td>Not mutagenic.</td><td>37</td></tr>
<tr><td>-</td><td>Test with Salmonella Typhimurium TA98.</td><td>With microsome.</td><td>-</td><td>Mutagenic.</td><td>16</td></tr>
<tr><td>-</td><td>Modified Ames Test</td><td>~~Modified Ames Test~~</td><td>-</td><td>Negative mutagenic response.</td><td>84</td></tr>
<tr><td>Compound dissolved in dimethyl sulfoxide, concentrations range with estimated ID 50 as the median dose.</td><td>Mammalian assay L5178Y mouse lymphoma thymidine kniase assay. TK^{+-} 3.7.2C cells grown in RPMI-1640 media with horse serum, sodium pyruvate, F-68 pluronic, penicillin and streptomycin.</td><td>With or without aroclor induced or noninduced S9 fraction.</td><td>Treatment for 72 hours.</td><td>Not mutagenic with S9. The observed data are the following:
<table>
<tr><th>Concentration Molarity</th><th>Mutants Per 10^4 Survivors</th></tr>
<tr><td>0</td><td>0.33</td></tr>
<tr><td>0.96×10^{-5}</td><td>0.28</td></tr>
<tr><td>1.27×10^{-5}</td><td>0.24</td></tr>
<tr><td>1.70×10^{-5}</td><td>0.43</td></tr>
<tr><td>2.27×10^{-5}</td><td>0.44</td></tr>
<tr><td>3.03×10^{-5}</td><td>0.45</td></tr>
<tr><td>4.05×10^{-5}</td><td>0.54</td></tr>
<tr><td>5.40×10^{-5}</td><td>0.57</td></tr>
<tr><td>7.20×10^{-5}</td><td>--</td></tr>
</table>
Geometric mean number of mutants per plate for 20% or more survival was 46.12. Control had 46.76.</td><td>132</td></tr>
</table>

CARCINOGENICITY

PAH: Anthracene C.A.S. NO: 120-12-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1 mg. in beeswax or tricaprilin medium.	Osborne Mendel Rats.	Intra pulmonary.	-	65% carcinoma incidence in rats.	68
2 mg in crushed paraffin wax.	Mice.	Bladder implantation.	-	17 carcinomas and 1 papillomas in the bladders of 52 mice surviving 40 weeks or more.	137
0.5mg in mineral oil	Mice.	By stomach tube.	Single administration	No tumors in 13 mice observed for 16 months	
			8 or 16 administrations at 3-7 days intervals.	Papillomas, in 2 out of 27 mice, of forestomach.	
50ug in 1% aqueous gelatin	Newborn mice and 2-9 days old mice.	-	Single injections.	Induction of pulmonary adenomas and adenocarcinomas with more tumors in new born mice.	137
Saturated solution in acetone	Rats.	Painting	Daily for 5 months.	No tumors developed in 9 rats that survived for 18 months.	137
Asdecane solution and as toluene solution.	Mouse.	Skin	-	The compound is a complete carcinogen. Tumors formation was higher with dodecane than toluene. It is attributed to co-carcinogenic effect of dodecane.	137

PAH: Benz(a)anthracene C.A.S. NO: 56-55-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
In benzene	Mice	Painting		1 regressing papilloma; 50 mice were tested.	137
2% solution of benzene	Mice	-	-	1 epithelioma; 80 mice were tested.	137

PAH: Benzo(a)anthracene C.A.S. NO: 56-55-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Mice	Treatment on mouse skin.	-	0.9 tumors/umole were initiated on skin. 2 p.mole/mg DNA reacted with mouse skin DNA.	1
As benzo(a) anthracene dihydrodiol.	Mice.	Skin.	-	Iball index of skin tumor formation (which is a measure of carcinogenicity) = 5.	1
Doses per mouse:	Mice	Subcutaneous injection in 0.5ml tricaprylin.	Single injection.	Tumor incidence responses were dose related. % mice with tumors at the respective doses per mouse were the following.	3
44.7ug				16%	
109.8ug				20%	
750ug				50%	

PAH: Benzo(a)fluoranthene C.A.S. NO: 205-99-2

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Doses per mouse:	Mice	Subcutaneous injection in 0.5ml tricaprylin.	Single injection.	Tumor incidence responses were dose related. % mice with tumors at the respective doses per mouse were the following	3
10ug				19%	
42.6ug				24%	
207ug				29%	
662ug				58%	
1 mg with beeswax or tricaprylin medium	Osborne Mendel rats.	Intra pulmonary	-	30% carcinoma incidence in the rats.	68
0.5,0.1 or 0.01% solution in acetone	Mice	Painting	Thrice weekly.	0.5% dose produced papillomas in all mice and carcinomas in 90% of mice tested in 8 months. 0.1% dose produced papillomas in 65% of mice and carcinomas in 85% of mice in 12 months. 0.01% dose produced papilloma in 1 animal out of 10.	137
0.6mg	Mice	Subcutaneous	3 injections over 2 months	18 of 24 surviving mice developed sarcoma at the injection site with average latency period of 4.5 months.	137

PAH: Benzo(b)fluoranthene C.A.S. NO: 205-99-2

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Automobile exhaust condensate hydrocarbons mixture.	-	-	-	Carcinogenicity of the mixture is attributed to the presence of PAHs including benzo(b)fluoranthene.	137

PAH: Benzo(j)fluoranthene C.A.S. NO: 205-82-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Doses per mouse:	Mice	Subcutaneous injection in 0.5ml tricaprylin.	Single injection.	Tumor incidence responses were dose related. % of mice with tumors at the respective doses per mouse were the following:	3
42.6ug				20%	
109.8ug				33%	
750ug				48%	
3170ug				70%	
1 mg with beeswax or tricaprylin medium	Osborne Mendel rats.	Intra pulmonary	-	Dose related responses. 10% carcinoma incidence in rats.	68

PAH: Benzo(k)fluoranthene C.A.S. NO: 207-08-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Doses per mouse	Mice	Subcutaneous injection in 0.5ml tricaprylin.	Single injection.	Tumor incidence responses were dose related. The % mice with tumors at the respective doses per mouse were the following:	3
10ug				6.46%	
34.1ug				12.5%	
100ug				15%	
1 mg with beeswax or tri-caprylin medium	Osborne Mendel rats	Intra pulmonary	-	Dose related responses. 11% carcinoma incidence in rats.	68

PAH: Benzo(ghi)perylene C.A.S. NO: 191-24-2

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1 mg in beeswax or tricaprylin medium	Osborne Mendel rats	Intra pulmonary	-	5% carcinoma incidence in rats, which is not significant.	68

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
-	Mice	Treatment on mouse skin.	-	25 tumors/u mole were initiated on skin. 25 p.mole/mg DNA reacted with mouse skin DNA.	1
As benzo(a) pyrene dihydrodiol	Mice	Skin	-	1 ball index of skin tumor formation, which is a measure of carcinogenicity = 70.	1
Dose per mouse:	Mice	Subcutaneous injection after dissolving in 0.5ml tricaprylin	Single injection.	Tumor incidence responses were dose related. The % of mice with tumor were	3
1.05ug				3.13% at 1.05ug/mouse;	
3.69ug				19.8% at 3.69ug/mouse;	
10ug				40% at 10ug/mouse;	
34.1ug				60% at 34.1ug/mouse;	
100ug				and 81.5% at 100ug/mouse.	
Benzo (a)pyrene and other constituents of anthracite briquettes combustion particles cyclohexane extracts.	Mice	Subcutaneous; single injection each of total extract and PAH fraction.	Single injections.	% of mice with tumors increased with increasing doses. % of mice with tumors increased linearly with increase in contents of benzo-(a)pyrene in doses.	3

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Benzo(a)pyrene and other constituents of automobile exhaust condensate.	Mice	Subcutaneous injection of condensate.	Single injection.	% mice with tumors increased with increasing doses. % of mice with tumors in parentheses and corresponding doses of benzo(a) pyrene per mouse were the following: 3.3ug(38%); 9.95ug(59%); 30ug(72%).	3
Doses per mouse: 3.3ug 9.95ug 30ug	Mice	Subcutaneous injection	Single injection	% of mice with tumors increased. The % at the respective doses per mouse were the following: 13.5% 39% 62%.	3
Benzo(a)pyrene and other constituents of airborne particulates extract. Total extract dose per mouse as ug Benzo(a)pyrene: 0.16 0.63 2.50 10.0	Mice	Subcutaneous injection of total extract.	Single injection	% number of mice with tumors increased with increasing dose. The % tumor responses were lower with extracts from particulates from rural areas. The % mice with tumors at the indicated doses corresponding to two sets of samples of urban aerosols were: 18.3 and 10.3; 31.7 and 31.7; 65.5 and 61.0; 68.3 and 39.2. Similar % for rural aerosols were: 16.7 and 10.3; 25.9 and 20.0; 39.0 and 20.0; 32.1 and 17.8.	3

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
PAH fraction of the extract as µg benzo-(a)pyrene per mouse. 0.16; 0.63; 2.5 and 10.	Mice	Subcutaneous injection	Single injection	% mice with tumors corresponding to two sets of urban aerosols samples were: 8.5 and 15.3; 13.6 and 20.3; 28.8 and 26.7; 55.9 and 45.8. Similar % of mice with tumors corresponding to rural aerosols were: 8.6 and 13.8; 16.9 and 33.3; 30.0 and 33.3; 35.6 and 43.3.	3
12.5ug of Benzo(a)pyrene and PAH fraction of urban particulates to a total of 375 ug.	Hamsters	Instillation in trachea.	-	Tumors were observed in the respiratory tract of 9 out of 46 hamsters.	3
Benzo (a)pyrene and Dibenz-(a,h) anthracene	Mice	Instillation in trachea.	-	Induced benign and malignant tumors in lung. Larynx and trachea were insensitive.	3
Up to 9.5mg/m^3		Inhalation	3 hrs/day; 5 days/wk for life.	Tumor formation in the respiratory tract.	3

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Total average dose of 100mg/ animal.	Syrian hamsters	Inhalation	-	Increased tumors of larynx, nasal cavity and trachea.	8
With SO_2	Rats.	Exposed	-	Increased formation of the Squamous cell carcinoma of the lung. Skin tumor formation activity of ++ on a + to ++++ scale.	15
0.005% of BaP in toluene and 0.2% of BaP in toluene as 50ul quantities.	Mice	Interscapular region of the backs of 50 mice and 30 mice respectively after removal of hair.	2 to 3 times per week.	Papillomas in 6 mice and carcinoma in 1 mouse in 0.005% BaP test. Calculated latent period was 80±8 weeks. Papillomas in 3 mice and carcinoma in 27 mice in the 0.2%PaB test. Average calculated latent period was 31±4 weeks.	14
200, 100 and 50 n.mole	Sencar mice.	Skin TPA as promoter at 5ug twice weekly, 1 week after initiation.		100%, 78%, 60% of mice at the respective doses developed papillomas at 15 weeks. Carcinomas developed in 55%, 30% and 18% of mice respectively.	16
Doses in ug per mouse: 0, 2.52, 12.6, 50.5 and 101 in 0.2 ml acetone	Sencar Mice	Shaved skin	Single topical application	% male mice; with papillomas, and with carcinomas at the respective doses were respectively; 8, 45, 73, 100, 95 and 5, 5, 20,25, 30. The respective % for female mice were: 5, 31, 57, 75, 97 and 0, 5, 23, 20, 25.	16

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Doses in ug/mouse per week: 0, 12.6, 25.2, 50.5, 101 and 202 in 0.2ml acetone			Weekly or twice weekly for 50 to 52 weeks.	% of male mice with carcinomas at the respective doses were 0, 10, 63, 93, 80 and 80. % female mice with carcinomas at the respective doses were 0,8, 43, 98, 90 and 93.	16
2.2, 9.5 or 45.6 mg/m^3 to a total dose of 29, 127 or 383 mg.	Syrian hamsters	Exposed	3 to 4.5 hrs/day; 7 days/wk.	Severe toxic effects and neoplasms were observed at the highest exposure level. Neoplasms were observed in the trachea and larynx. Bronchial or lung tumors were not observed.	23
Benzo(a)pyrene and SO_2	Syrian hamsters	-	-	Increased incidence of Squamous cell carcinomas.	23
0.2u. moles	9 weeks old female CD-1 mice	Dorsal skin	Every other day for a total of 10 times.	Developed tumors which were larger than that developed when cyclopenta(c,d)pyrene is applied at the same dose of 0.2 u.moles. The % of mice with papillomas was 40. and 1.20 as tumor/mouse. The induced tumors included 1 Keratocarcinoma, 1 basal cell carcinoma and one Squamous cell carcinoma	40

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
In acetone and skin cells were later treated with labelled 3H-thymidine	Human neonatal foreskin fibroblast cells.		In contact with cells for 8.2 hours during S phase of the cell cycle.	Neoplastic transformation of cells at a concentration of 3.2ug/ml. Seeding of treated cells onto chick embryonic skin cells caused fibrosarcoma in chick cells.	39
-	Ames test	-	-	Mutagenic	37
-	Mammalian mutagenicity assay by bone marrow micronucleus test protocol with B6C3 F1/BR hybrid mice.	-	-	Mutagenic	37

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
High, medium, low doses singly or in mixture with high medium, low doses of cyclopenteno-(c,d) pyrene 20, 6.6, 2.2 n. moles were the doses of B(a)P 200, 66.6, 22.2 n. moles were the doses of CPEP.	9 weeks old female Swiss mice.	On the back in 50ml in acetone.	Twice weekly for 48 weeks.	Due to high tumor incidences at the high doses of B(a)P and CPEP and low tumor incidences at the low doses of B(a)P and CPEP, synergistic carcinogenic effects were not observed at these doses. A significant 3 to 7 fold increase as syncarcinogenic effect was observed with B(a)P medium + CPEP (medium) doses. Significant syncarcinogenic effects were also observed with combinations of medium and low doses of B(a)P and CPEP. At the high doses of B(a)P and CPEP; malignant skin tumors were observed. Tumors when the compounds were administered singly were lower than when the compounds were administered as mixtures.	67
Doses in beeswax or tricaptrylin medium.	Osborne mendel rats.	Intra pulmonary	-		
0.1mg			-	10% carcinoma and 30% carcinoma and sarcoma incidences in rats.	
0.3mg			-	60% carcinoma and 70% carcinoma and sarcoma incidences in rats.	
1.0mg			-	90% carcinoma and 90% carcinoma and sarcoma incidences in rats.	

PAH: Benzo(a)pyrene C.A.S. NO: 50-32-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
B(a)P + CPEP as indicated in CPEP.	As indicated in CPEP.	-	-	Data same as in reference 67. Additional details given in CPEP.	133

PAH: Benzo(e)pyrene C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
1.0mg in acetone	Mice	Skin	Single application	No tumors in an experiment lasting 64 weeks. When this experiment was followed with repeated paintings of croton resin, 2 out of 20 mice developed 1 papilloma each.	137
0.1% solution in acetone	Mice	Painting	3 times weekly	2 papillomas and 3 carcinomas in 8 mice surviving after 10 months. No mice survived after 14 months.	137
252mug	Mice	-	40 weeks	Weak tumor induction activity.	137
100 mug	Mice	-	40 weeks	No tumor induction	137
100mug	Mice	-	Twice/week	2.1 papillomas per mouse at 30 weeks. 25% mice developed carcinomas at 40 weeks.	137
B(e)P + Dimethyl benzoanthracene	-	-	-	Moderate tumor promotion	137

PAH: Benzo(e)pyrene C.A.S. NO: 192-97-2

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
	Mice	Subcutaneous injection after dissolving in 0.5ml tricaprylin	Single injection	Not carcinogenic up to a dose of 800ug.	3
Doses in beeswax or tricaprylin medium	Osborne Mendel rats.	Intra pulmonary	-	No tumors up to a dose of 5 mg of implanted compound.	68

PAH: Chrysene C.A.S. NO: 218-01-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Dose per mouse: 29.5ug 100ug 276ug 765ug 3170ug	Mice	Subcutaneous injection in 0.5ml tricaprylin	Single injection	Tumor incidence responses were dose related. % mice with tumors at the respective doses per mouse were the following: 4.25% 14% 10% 18% 30%	3
0.20% in acetone	Mice	Dermal, intrascapular region	Twice weekly for 31 weeks	One out of twenty tumor bearing mouse. The mean latency period was determined as 31 weeks.	136
0.1mg in 0.1 ml acetone	Mice	Shave backs	3 times per week for 72 weeks.	Four of the eleven surviving mice had skin carcinomas. Three mice had leukemia. 5 mice had 7 lung adenomas. Chrysene was considered a weak carcinogen.	136
100ug/treatment in polyethylene glycol 400	Mice	Subcutaneous	One injection daily for first 3 days of life.	Increased liver tumors incidence. No increase in lung tumors incidence.	136
0.2, 0.4, 0.8u. mol.	Mice	Intraperitoneal	3 injections on days 1,8 and 15 of life	25% increase in liver tumors incidence. 17% increase in pulmonary tumors incidence compared to 15% in control.	136

PAH: Chrysene C.A.S. NO: 218-01-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
2u.mol. + TPA + dihydrodiols and diol-epoxides of chrysene as initiators in vehicles	Mice	Dermal	Single application	Chrysene, diol and diol epoxides of chrysene initiated skin tumors. The numbers of mice developing such tumors are given in the reference.	13
2u.mole in 200m/ solvent. + TPA after 7 days after chrysene treatment.	Mice	Dermal	Single application	Increased incidence of skin papillomas. Induced tumors in 67% of animals, after 25 weeks of treatment with promoter (~~TPA)~~. (TPA)	13

PAH: Cyclopenteno(c,d)pyrene C.A.S. NO: 27208-37-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Minimum of 1.8, 0.6 and 0.2u. moles	Mice 9 weeks old; female CD-1.	Dorsal skin	Every other day for a total of 10 times	Developed tumors. Tumors at 0.2u.moles were less than that induced by benzo(a)pyrene at the same dose of 0.2u.moles. % of mice with papillomas at the respective doses were 21, 31 and 3. Tumors per mouse were 0.31, 0.31 and 0.03.	40
High, medium, low doses singly or in mixture with high, medium, low doses of benzo (a)-pyrene. 200, 66.6, 22.2n. moles were the doses of CPEP and 20, 6.6, 2.2 n.moles were the doses of B(a)P.	9 weeks old female Swiss mice.	On the back in 50ul acetone	Twice weekly for 48 weeks.	Due to high tumor incidences at the high doses of B(a)P and CPEP and low tumor incidences at the low doses of B(a)P and CPEP; synergistic carcinogenic effects were not observed at these doses. A significant 3 to 7 fold increase as syncarcinogenic effect was observed with B(a)P medium dose + CPEP medium dose. Significant syncarcinogenic effects were also observed with ~~concentrations~~ combinations of medium and low doses of B(a)P and CPEP. At the high doses of B(a)P and CPEP, malignant skin tumors were observed. In the high CPEP dose group, metastasis to the lungs and lymph nodes was observed. Tumors, when the compounds were administered singly, were lower than when the compounds were administered as mixtures.	67

PAH: Cyclopenteno(c,d)pyrene C.A.S. NO: 27208-37-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
High, medium, low doses of cyclopenta-(c,d) pyrene and benzo (a) pyrene; singly or as mixtures. The high, medium, low doses of cyclopenta (c,d) pyrene were respectively 200, 66.6, 22.2n. moles. The respective doses of benzo (a) pyrene were 20, 6.6 and 2.2n. moles	9 weeks old Swiss female mice in groups of 30.	dose in 50 ul acetone on the back	Twice weekly for 48 weeks.	3 to 7 fold synergistic carcinogenic effect in groups treated with CPEP-M+B(a)P-M doses. No syncarcinogenic effects were observed in B(a)P-H +CPEP-H and B(a)P-L + CPEP-L. Malignant tumors predominated in B(a)P-H or CPEP-H group; tumors metastasized to the lungs and lymph nodes. In CPEP-H + B(a)P-H and CPEP-M + B(a)P-M groups, malignant tumors were six times more than benign tumors. 1.2 to 3.8 synergistic carcinogenic effects were observed in CPEP-L + B(a)P-M and CPEP-M + B(a) P-L groups. Most of the tumors were malignant. The latter group, tumors metastasized to the lung and/or lymph nodes. Mice given B(a)P or CPEP alone had lower number of tumors with relatively long latency periods. High incidence of malignant tumors in the combined high doses group prevented evaluation of synergistic carcinogenic effect. In the B(a)P-H + CPEP-L and B(a) P-L +CPEP-H groups tumors were Squamous cell carcinomas with metastasis to lung and/or lymph nodes. Major tumors developed in all the groups can be differentiated into papillomas, sebaceous	13

PAH: Cyclopenteno(c,d)pyrene C.A.S. NO: 27208-37-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
				gland adenomas, Squamous cell carcinoma, basal cell carcinomas. Other neoplasms were; subcutaneous fibrosarcoma, lung adenomas, lung adenocarcinoma, malignant lymphoma, luteinoma, uterine leiomyoma, mamary fibroadenoma, lung adenosquamous cell carcinoma; angiosarcoma in liver; granulosa cell carcinoma, cystoma in the ovary, cholangioma in liver, lei omyosarcoma in uterus. The ratio of observed tumor incidence between the CPEP-H (200n.mole) and B(a)P-H (20n.mole) groups ranged from 5.2 to 1.6. At concentrations of greater than 200 n.moles of CPEP tumor incidence decreased due to cytotoxicity. The combined carcinogenic effect of CPEP and B(a)P and assuming a synergistic carcinogenic effect of 2.5; these two compounds account for most of the carcinogenicity of automobile exhaust emissions.	

PAH: Dibenz(a,h)anthracene C.A.S. NO: 53-70-3

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
100 n.moles one week later, TPA twice weekly at 2ug/application	Mice	Dermal	Single application	At 15 weeks, 29 mice were alive. About 15 mice had papillomas. The compound is considered a strong skim tumors initiator.	13
Doses per mouse:	Mice	Subcutaneous injection in 0.5ml tricaprylin.	Single injection.	Tumor incidences were dose related. % of mice with tumor at the respective doses were the following per mouse:	3
0.412ug				18%	
3.17ug				32%	
10ug				58%	
242ug				85%	
Benzo-(a) pyrene and dibenz (a,h) anthracene	Mice	Instillation in trachea	-	Induced benign and malignant tumors in lung. Larynx and trachea were insensitive.	3
Total doses of 0, 0.5, 2,10,20 mg. in protein blood substitute BK-8 with finely powdered black India ink.	Rat	Intratracheally	5 injections and observations for 30 months.	Ratios of animals with squamous cell carcinomas of the lung to the number of animals surviving at the appearance of first tumor were 0/15, 0/18, 1/27, 4/21, 6/13 respectively at the respective total doses.	13

PAH: Dibenzo(a,i)pyrene C.A.S. NO: 189-55-9

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
In acetone; 2.5ug TPA in 0.1 ml acetone/wk was applied after initiation	Mice; Swiss albino female	Application on shaved skin	One subdose every other day in 10 subdoses.TPA for 20 weeks after initiation	Tumor initiation. Tumor initiating dose in test 1 was 100ug and in the second test was 500ug.	35

PAH: Indeno(1,2,3-cd)pyrene C.A.S. NO: 193-39-5

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Doses in 0.5ml tricaprylin	Mice	Subcutaneous injection	Single injection	The compound was relatively less carcinogenic with activity similar to chrysene. For chrysene tumor incidence responses were dose related.	3
1mg in beeswax or tricaprylin	Osborne Mendel rats.	Intra pulmonary	-	30% carcinoma incidence in rats.	68

PAH: 3-Nitrofluoranthene C.A.S. NO: 892-21-7

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
2mg; twice weekly 15 times as a solution in dimthylsulfoxide.	Fischer F344 rats.	Subcutaneous injection		4 rats out of 10 developed tumors on days 277, 277, 298 and 319 days after the first injection.	15

PAH: 1-Nitropyrene C.A.S. NO: 5522-43-0

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
2mg, twice weekly, 20 times as a solution in dimethyl sulfoxide.	Fischer F344 rats	Subcutaneous injection	As indicated in dose.	8 rats out of 17 developed tumors on days 162, 186, 200, 221, 269, 269, 330 and 333 days after the first injection.	15

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Passenger car exhaust condensate; fractionated and reconstituted. Beeswax or tricaprylin were used as medium Condensate (10.0 mg)	Osborne Mendel rats	Intra pulmonary		PAH containing pellets caused keratinized squamous cell carcinomas in several cases with occasional infiltration into the chest wall. Sporadic fibrosarcoma with infiltration into chest wall were observed.	68
PAH fraction containing more than three ring, compounds (0.28mg) Reconstituted condensate			- - -	58% carcinoma incidence 42% carcinoma incidence 60% and 55% carcinoma incidences respectively for the above two cases have been observed by skin painting 38% carcinoma incidence.	

PAH: PAH C.A.S. NO:

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Urban atmospheric particlates benzene extracts in tricaprylin. 1 day old:3.1 mg/g 7 days old:2.0 and 3.0 mg/g 14days old:1.1, 1.7,2.2, 2.8 mg/g	Mice: Swiss albino (ICR/Ha) aged 1,7 and 14 days	Subcutaneous in the nape of the neck.	Mice were sacrificed between 49 and 52 weeks of age.	Dose related tumor incidence. Pulmonary tumors included solitary adenoma; multiple adenomas; and adenocarcinoma. Hepatocellular carcinoma or neoplastic nodule; lymphoma were induced. Other tumors were fibrosarcoma at injection site; angiofibrosarcoma, myosarcoma; hemangioma, malignant mixed tumor of kidney; mammary adenocarcinoma. The % of mice with tumors varied from 20% in 14days old male mice given a total dose of 10mg to 56. 86% in 1, 7 and 14 days male mice given total doses respectively of 5mg, 10mg and 10mg. For the female mice, the low-high % of mice with tumors were 21.74% in 1 day old mice given a total dose of 5mg to 79.17% in 1, 7 and 14 days mice given total doses respectively of 5mg, 15mg and 20mg. The % of tumor bearing mice in ~~that~~ no treatment group were: 15.63% for male mice and 2.86% for female mice. For solvent treated group, the %s were 15.91% for male mice and 10.53% for female mice. There were no pulmonary multiple adenomas or adenocarcinoma in control.	1

PAH: Phenanthrene C.A.S. NO: 85-01-8

DOSE	SPECIES	ROUTE	PERIOD	EFFECT/RESPONSE	REF
Phenanthrene dissolved in 90% benzol.	Mice	Skin	-	No increase in tumors	13
-	Mice	Topical	-	No increase in tumors	13
0.2uM on day 1; 0.4uM on day 8 and 0.8uM on day 15 after birth	Mice	Intraperitoneal	Once a week for two weeks.	Pulmonary tumor incidence of 17%. No hepatic tumors. 6% of female mice had other neoplasms. Pulmonary tumors were statistically significant.	13
150mg/kg	Fischer 344 rats	Oral in corn oil 12 hours after a partial hepatectomy	-	No induction of focal lesions of proliferation, which is characteristic of carcinogenic PAH.	136
3.0mg/100g body weight	Pregnant hamsters	Intraperitoneal; 10th day of gestation.	-	Not carcinogenic	136

Acute Toxicity and Other Toxic Effects

Anthracene

Mice: Dermal ~~LD50~~ ID50 (Irritant Dose to 50% of the population) = 6.6×10^{-4} millimolar/ear (Ref: 136)

Guinea Pigs: 0.9% solution of the compound in ethanol was applied to the shaved skin of guinea pigs. 33 minutes after application to the skin, shaved and which was depilated, guinea pigs were expored to non-eryth~~hy~~rogenic radiation from black fluorescent light. All amimials showed erythema, which is attributed to phototoxic reaction. (Ref. 136)

Guinea Pigs: Treatment of skin with 50ml of 0.025% anthracene in 20% pyrrolidone and 80% in propyl alchol and subsequent exposure of the treated skin to long wave length ultraviolet radiation resulted in erythema and an increase in permeability of vascular tissue. The erythema is not mediated by histamine or serot~~a~~onin. These medi~~c~~ate increased permeability of vascular tissue. (Ref. 136)

Acheta Domesticus: (Cricket)(4 weeks old) 24hr LD50 > 580~~mg~~ug/g food in diet

Cricket: Oral route, dose: 0.1% in diet, continuously for life. Results: Lethal time in days for 50% mortality (LT50) was greater than 12 days. 39% mortality occurred at 12 days at the administered dose level. (Ref. 136)

Rats: Subcutaneous TDLO: 33mg/kg/33 intermittent weeks neoplastic effects. (Ref. 137)

Rats: Oral TDLO: 18g/kg/78 intermittent weeks, carcinogenic effects. (Ref. 137)

Anthracene -9,10 - dione

Rats: Intraperitoneal LD50: 3500mg/kg. (Ref. 137)

Benz(c) acridine

Mice: Dermal TDLO: 468mg/kg26 intermittent weeks, carcinogenic effects.

Benz(a) anthracene

Mice: Sub~~en~~cutaneous TDLO: 2mg/kg tumor inducing compound. (Ref. ~~130~~ 137)

Mice: Intravenous LDLO: 10mg/kg. (Ref. 137)

Mice: I~~n~~mplantation TDLO: 80mg/kg, carcinogenic effect. (Ref. 137)

7H - Benz(de) anthrace -7- one

Rabbits: Dermal: 500mg/24 hours, Irritant Dose, skin irritation. (Ref. 137)

Rabbits: Occular: 100~~mg~~ug/24 hours, Irritant Dose, severe eye irritation. (Ref. 137)

Rats: Intraperitoneal LD50: 1500mg/kg. (Ref. 137)

Mice: Intraperitoneal LD50: 290mg/kg. (Ref. 137)

Occupational Exposure in 1,9 - Benzathrone manufacture: An increase of 5 to 22.6% increases respectively in the diseases of the liver and the bile duct; 20.5% of workers experienced cardiovascular diseases, induction of photodermatitis, decrease of hemoglobin and erythrocytes levels in blood. (Ref. 137)

Benzo(b) fluoranthene

Mice: Percutaneons TDLO: 40mg/kg; carcinogenic effects.

Mice: Sub~~en~~cutaneous TDLO: 72 mg/kg/9 weeks; carcinogenic effects. (Ref. 137)

Benzo(~~y~~j) fluoranthene

Mice: Percutaneous TDLO: 288mg/kg/24 intermittent weeks; ~~tumor~~ tumor ~~producing compound~~. (Ref. 137); carcinogenic effects

Mice: Sub~~er~~cutaneous TDLO: 72mg/kg/for 9 intermittent weeks; tumor Producing compound. (Ref. 137)

Benzo(a) pyrene

Rats: Oral TDLO: 4563 mg/kg/52 weeks, neoplastic effects. (Ref. 137)

Rats: Sub~~en~~cutaneous LD50: 50mg/kg. (Ref. 137)

Rats: Intraperitoneal TDLO: 16mg/kg; carcinogenic effects. (Ref. 137)

Rats: Sub~~en~~cutaneous TDLO: 250~~mg~~µg/kg; neoplastic effects. (Ref. 137)

Rats: Intravenous TDLO: 38mg/kg/6 days; neoplastic effects. (Ref. 137)

Mice: Intrapenitoneal TDLO: 10mg/kg; carinogenic effects. (Ref. 137)

Mice: Intravenous TDLO: 10mg/kg; carcinogenic effects. (Ref. 137)

Benzo(e) pyrene

Mice: Percutaneous TDLO: 516mg/kg/ for 43 weeks; carcinogenic effects. (Ref. 137)

Mice: Subentaneous TDLO: 160mg/kg; neoplastic effects. (Ref. 137)

Guinea Pigs: Sub~~en~~cutaneous TDLO: 140mg/kg for intermittent 32 weeks; newplastic effects. (Ref. 137)

Biphenyl

Rats: Oral LD50: 3280mg/kg. (Ref. 137)

Mice: Sub~~en~~cutaneous TDLO: 46mg/kg; neoplastic effects. (Ref. 137)

Mice: Intravenous LD50: 56mg/kg. (Ref. 137)

Chrysene

Mice: 24 hours Intramuscular LD50 = 320mg/kg. (Ref. 136)

Mallard Duck Eggs: Coated with aliphatic hydrocarbon mixture or aromatic hydrocarbon mixture containing 0.5% chrysene.
Results: In the group treated with ~~one~~ the mixture containing chrysene, the number surviving with abnormalities was higher. These abnormalities included reduced weight, decrease in crown-rump length and bill length. (Ref. 136)

Mice: Sub~~en~~cutaneous TDLO = 200mg/kg; carcinogenic effects. (Ref. 137)

Mice: Percutaneous TDLO = 99mg/kg/for 31 intermittent weeks neoplastic effects. (Ref. 137)

Dibenz(a,h) acridine

Mice:	Oral TDLO = 18mg/kg/89 weeks, carcinogenic effects. (Ref. 137)
Mice:	Dermal: TDLO = 700mg/kg/for 29 intermittent weeks; neoplastic effects. (Ref. 137)
Mice:	Subentaneous TDLO = 430mg/kg/ for 24 intermittent weeks; neoplastic effects. (Ref. 137)
Mice:	Intravenous TDLO: 10mg/kg/ carcinogenic effects. (Ref. 137)

Dibenz (a,j) acridine

Mice:	Dermal TDLO: 11mg/kg/ 35 weeks; neoplastic effects. (Ref. 137)
Mice:	Sub~~en~~cutanous TDLO: 40mg/kg; carcinogenic effects. (Ref. 137)

Dibenz (a,h) anthracene

Mice:	Oral TDLO: 36mg/kg/ 22 weeks; carcinogenic effects. (Ref. 137)
Mice:	Sub~~en~~cutaneous TDLO: 76~~mg~~ug/kg; carcinogenic effects. (Ref. 137)
Rats:	Sub~~en~~cutanous Toxic Dose: 450~~mg~~ug/kg; tumor producing compound. (Ref. 137)

Dibenz (a,h) pyrene

Mice:	Perc~~en~~utanous TDLO: 165 mg/kg/ 24 weeks, carcinogenic effects. (Ref. 137)

Dibenz (a,i) pyrene

Mice:	Percutaneous TDLO: 80mg/kg/ for 44 intermittent weeks; carcinogenic effects. (Ref. 137)
Hamsters:	Intraperitoneal TDLO: 40mg/kg/ for 8 intermittent weeks; carcinogenic effects.

Fluoranthene

Rats:	Oral LD50 = 2000mg/kg. (Ref. 137)
Mice:	Intravenous LD50 = 100mg/kg. (Ref. 137)
Mice:	Percutaneous TDLO = 280mg/kg/ 58 intermittent weeks; tumor producing compound. (Ref. 137)

9 - Fluorenone

Rats: Subentaneous TDLO = 300 mg/kg/ for 26 intermittent weeks; tumor producing compound. (Ref. 137)

Indeno (1,2,3 - cd) pyrene

Mice: Subentanous TDLO = 72mg/kg/ for 9 intermittent weeks; carcinogenic effects. (Ref. 137)

1 - Methyl naphthalene

Rats: Oral LDLO = 5000mg/kg. (Ref. 137)

2 - Methyl naphthalene

Human Lethal Dose = 0.5 - 5gms/kg. (Ref. 137)

Phenanthrene

Mice: 24 hours oral LD50 = 700mg/kg. (Ref. 137)

Humans: Allergen; causes skin photosensitization, acute local irritant causing readily reversible changes. (Ref. 136)

Mice: Oral LD50 = 700 mg/kg. (Ref. 137)

Mice: Percutaneous TDLO = 71mg/kg; neoplastic effects. (Ref. 137)

Mice: Percutaneous Toxic Dose = 22g/kg/ for 10 intermittent weeks; tumor producing compound. (Ref. 137)

Pyrene

Dermal TDLO = 10g/kg / for 3 intermittent weeks; neoplastic effects. (Ref. 137)

Risk Analysis

Information in this area, with particular reference to polyaromatic hydrocarbons of environmental interest is limited. Review of references other than reference 81 is to be considered outside the scope of this project.

In reference 81 a model is recommended to determine allowable daily intake of PAHs, taking into consideration the risk from the intake of PAHs. The following is a summary of that reference 81.

Human exposures to PAHs occur from air, water, food and tabacco smoking. Human exposure from air is determined from air quality monitoring data and volume of air ~~initiated~~ inhaled ·15m³ for a 10 year old child to 23m³ for an adult man is the daily ~~intilation~~ inhalation intake of air suggested with an average value of 19m³. Knowing the water and food consumption habits and levels of PAHs in these media, human daily intake from these media can be determined. The following data on human exposure estimates in ~~ng~~ ug/day are reproduced from the reference (81). Carcinogenic PAH is the total of benzo(a) pyrene, benzo(j) fluoranthene and indeno (1,2,3-cd) pyrene.

Media	Benzo(a) pyrene	Carcinogenic PAH	Total PAH
Air	0.0095-0.0435	0.038	0.207
Water	0.0011	0.0042	0.0270
Food	0.16 - 1.6	No data	1.6 - 16

The data are based on assumptions and therefore are not exact. Cancer risk is estimated from data on epidemiological studies, occupational and community air pollution and health effects studies. Site specific cancer risk, that is risk of cancer of the lung, risk of cancer of the blood and so on, may also be estimated.

Suggested methods associating air pollution and cancer risk are:

1) Urban - rural comparisons. An urban factor for cancer caused deaths is generally agreed to be present but this may not be air pollution dependent.
2) Migrant studies
3) Regression analysis of lung cancer death rates for residents with respect to gross indicators such as cigarettes smoked, industrialization and air pollution.
4) Retrospective and prospective analysis of data for sampled individuals with known individual exposures and background information.

Reasons for variations are suggested and a multimedia approach to determination of cancer risks is recommended. Determination of cancer risk for humans on the basis of animal ~~det~~ data is not exact. Errors occur and some are in the following areas.

1) Selection of test chemicals and route of administration.
2) High dose in animals is converted to low dose in humans.
3) Conversion of results from animals to humans.
4) Partitioning of acceptable dose within different environmental media.

Assuming a linear carcinogen~~ic~~esis dose response models, an equation for estimation of allowable daily intake is recommended. The equation is the following.

$$\text{ADI} = \frac{(d \times le \div Le) \times (Le \div L)^3 \times HBW \times (RL)}{\text{Ln}\left((1-P_t) \div (1-Pc) \right) \times (HBW \div W)^{1/3}}$$

It is a modification of a model developed by U~~sE-PA~~. USEPA

ADI = acceptable daily intake (mg)

d = dose (mg/kg/day)

le = length of exposure (days)

Le = duration of experiment - surviving animals sacrificed at the end

L = expected life span for test animals

HBW = human body weight (kg); (assume 70kg)

RL = additional risk over lifetime ($\frac{1}{100,000}$ is recommended)

Pt = proportion of test animals with tumors

Pc = proportion of control animals with tumors

W = average weight of test animals

The model estimates the intake of a compound which would result in an increase of $\frac{1}{100,000}$ in life time risk of development of cancer in a 70kg human. The model is based on chemical basis of carcinogenesis with assumptions that are discussed ~~with~~ in the reference (81). ADIs are calculated for selected ~~PAHs~~ PAHS and the results suggest that highest human exposure the PAH results through the diet. PAH levels in air and water do not constitute significant risk for cancer.

Standards

Information has been not found with respect to ambient air standards of PAHs from the references reviewed. Review of additional references is outside the scope of this project. The following for occupational air exposure have been found.

NIOSH recommendation for occupational exposure to coal tar products including coal tar ptich and creoste: Not greater than 0.1mg/m^3 of cyclohexane extractable fraction (reference 88).

OSHA Permissible Exposure Level: 0.2mg/m^3 for coal tar pitch volatiles of benzene soluble fraction (reference 88), reference 94 as 8 hrs - TWA.

ACGIH TLV, coal tar pitch volatiles: 0.2mg/m^3 as benzene solubles (Reference: ACGIH 1981 TLVS)

ACGIH TLV før asphalt fumes: 5mg/m^3 - TWA over 8 hours work shift. (Reference: ACGIH 1981 TLVS)
NIOSH recommendation for maximum exposure for asphalt fumes based on 15 minutes sampling period: 5mg/m^3 (Reference 93)

California/OSHA standard for asphalt fumes: 5mg/m^3 TWA over a work shift. (Reference 93)

U.S. Dept. of Labour recommendation to the Standards Advisory Committee on Coke Oven Emissions: Maximum exposure to benzo(a) pyrene to be set at 0.2~~mg~~ug/m^3 - TWA (Reference 93)

NISOH recommendation for coal tar pitch volatiles and the PNAs: 0.1mg/m^3 (8 hrs - TWA as cyclohexane solubles). (Reference 94)

Chrysene - occupational air exposure to be controlled as a potential occupational carcinogen~~ic~~ to the lowest detection limit. (Reference 94)

References

1. H. Bartsch and L. Tomatis; Comparison between carcinogenicity and mutagenicity based on chemicals evaluated in the IARC monographs; Environmental Health Perspectives; Volume 47; pp 305-317 (1983).

2. Jorma Rantanen; Community and occupational studies of lung cancer and polycyclic organic matter. Environmental Health Perspectives, Vol. 47; pp 325-332 (1983).

3. Friedrich Pott and Werner Stöber; Carcinogenicity of airborn combustion products observed in subcutaneous tissue and lungs of laboratory rodents; Environmental Health Perspectives; vol. 47; pp 293-303 (1983).

4. Ulf Rannig; Data from short term tests on motor vehicle exhausts; Environmental Helath Perspectives; Volume 47; pp 161-169 (1983).

5. Torben Nielsen et al; The fate of airborne polycyclic organic matter; Environmental Health Perspectives; volume 47; pp 103-114 (1983).

6. James N. Pitts, Jr.; Formation and fate of gaseous and particulate mutagens and carcinogens in real and simulated atmospheres. Environmental Health Perspectives, Volume 47, pp 115-140 (1983).

7. Ulf Stenberg; Emissions of carcinogenic components with automobile exhausts. Environmental Health Perspectives; Volume 47; pp 53-63 (1983).

8. Bo Holmberg and Ulf Ahlborg; Consensus Report:

   Mutagenicity and carcinogenicity of car exhausts and coal combustion emissions; Environmental Health Perspectives, Volume 47; pp 1-30 (1983).

9. M. Ahlborg et al; Chemical and biological characterization of emissions from coal and oil fired power plants; Environmental Health Perspectives; Volume 47; pp 85-102 (1983)

10. Dennis Schueltzle; Sampling of vehicle emissions for chemical analysis and biological testing; Environmental Health Perspectives; Volume 47; pp 65-80 (1983).

11. Yu, V. Pashin and L.M. Bakhitova; Mutagenic and carcinogenic properties of PAHs; Environmental Health Perspectives; Volume 30; pp 185-189 (1979).

12. G. Grimmer; Profile analysis of polycyclic aromatic hydrocarbons in air. Handbook of Polycyclic Aromatic Hydrocarbons; pp 149-181 (1983) Marcel Dekker Inc.

13. Alf Bjorseth and Bjorn Sortland Olufsen; Long range transport of polycyclic aromatic hydrocarbons; Handbook of Polycyclic Aromatic Hydrocarbons; pp 507-524 (1983) Marcel Dekker Inc.

14. I.A. Veldre and H.J. Janes; Toxicological Studies of stale oils; some of their components and commercial products; Environmental Health Perspectives; Volume 30; pp 141-146 (1979).

~~14. Curt M. White; Determination of Polycyclic Aromatic Hydrocarbons in coal derived from materials. Handbook of Polycyclic Aromatic Hydrocarbons, pp 525-616 (1983). Marcel Dekker Inc.~~

15. Richard B. Gammage; Polycyclic Aromatic Hydrocarbons in work atmsopheres; Handbook of Polycyclic Anomatic Hydrocarbons, pp 653-707 (1983) Marcel Dekker, Inc.

16. J.L. Epler et al. Evaluation of feasibility of mutagenic testing of stale oil products and effluents. Environmental Health Perspectives Volume 30; pp 179-184 (1979).

(17) E. Bingham and N. Barkley; Bioassay of complex mixtures derived from fossil fuels. Environmental Health Perspectives; volume 30; pp 157-163 (1979).

(18) C. Ramel; Advantages of and problems with short term mutagenicity tests for the assessment of mutagenic and carcinogenic risk. Environmental Health Perspectives; volume 47; pp 153-159 (1983).

(19) S. Nesnow et al; Mouse skin tumor irritation promotion and complete carcinogenesis bioassays. Mechanisms and biological activities of emission samples. Environmental Health Perspectives; Volume 47; pp 255-268 (1983).

(20) Ole Anderson; Effects of coal combustion products and metal compounds on Sister chromatid exchange in a macrophage like cell line; Environmental Health Perspectives; Volume 47; pp 239-253 (1983)

(21) I. Alfheim et al; Mutagenicity in emission from coal and oil fired boilers; Environmental Health Perspectives; Volume 47; pp 177-187 (1983).

(22) I. Alfheim et al; Bioassay of extracts of ambient particulate matter. Environmental Health Perspectives; Volume 47; pp 227-238 (1983).

(23) R.O. McClellan; Role of inhalation studies with animals in defining human risk roles for vehicle and power plant emissions; Environmental Health Perspectives; Volume 47; pp 283-292 (1983).

(24) T. Sugimura and S. Takayama; Biological actions of nitroarenes in short term tests or salmonella cultured mammalian cells and cultured human tracheal tissues. Possible basis for regulatory control. Environmental Health Perspectives; Volume 47; pp 171-176 (1983).

(25) J.J. Vostal; Bioavailability and biotransformation of the mutagenic component of particulate emissions present in motor exhaust samples; Environmental Health Perspectives; Volume 47; pp 269-281 (1983).

26A References from 5th International PAH Symposium

Polynuclear Anomatic Hydrocarbons - Chemical Analysis and Biological Fate. 5th International Symposium; held 1980; published 1981; Battelle Press.

(26) J.A. Peters et al; An environmental assessment of POM emissions from residential wood fired stoves and fire places; pp 571-581.

(27) Robert Langenback et al; Organ specific activation of carcinogenic
P PAHs in cell culture; pp 75-84.

(28) D.G. Nichols et al; Analysis and assessment of PAH from coal combustion and gasification; pp 397-406.

(29) R.G. Schimberg; Industrial hygienic measurements of PAHs in foundries; pp 755-762.

(30) R.R. Potvin et al; Ambient PAH levels near a steel mill in northern Ontario; pp 741-753.

(31) G. Prado et al; Formation of polycyclic aromatic hydrocarbons in premixed flames; chemical analysis and mutagenicity; pp 189-198.

(32) Lee D. Hansen et al; Chemical properties of bacterial ~~mentogens~~ mutagens in stack collected coal fly ash; pp 507-517.

(33) R.A. Hites et al; Compounds associated with diesel exhaust particulates pp 455-466.

(34) J. Oigiovanni and T.J. Slaga; Effects of benzo(e) pyrene and dibenz (a,c,) anthracene on the skin tumor initiating activity of polycyclic aromatic hydrocarbons; pp 17-31.

(35) S.S. Hecht et al; On the metabolic activation of dibenz(a,i) pyrene and benzo(a,h) pyrene; pp ~~45-53~~. 43-54.

(36) T.R. Barfknecht et al; Soot and mutation in bacteria and human cells; pp 231-242.

(37) M. Katz et al; Mutagenic activity of PAH and other environmental pollutants; pp 519-528

(38) G.F. Strinste and R.J. Blake; Cytotoxity in human skin fibroblasts induced by photoactivated polycyclic aromatic hydrocarbons; pp 109-118.

(39) F.D. Cazer et al; Human cell neoplastic transformation with B(a)P and a bay region reduced ~~avalogne~~ analogue of 7,12-dimethyl benz(a) anthracene; pp 499-506.

(40) E.L. Cavalieri et al; Carcinogenicity, mutagenicity and binding studies of the environmental contaminant cyclopenteno (c,d) pyrene and some of its derivatives; pp 487-498.

(41) S. Nesnow et al; Cyclopenta (c,d) pyrene; metabolism, mutagenicity and cell transformation; pp 387-396.

(42) M.V. Marshall et al; Effects of Selenium and sulfur on metabolism of benzo(a) pyrene by human pulmonary alveolar mairophages; pp 221-230.

(43) W.H. Geist and J.E. Caton; Studies of the interaction of polycyclic aromatic hydrocarbons with fly ash; pp 719-730.

44B References from 7th International PAH Symposium

Polynuclear Aromatic Hydrocarbons; Formation, metabolism and measurement; 7th International Symposium; held 1982; published 1983; Battelle Press.

(44) M. Toqan et al; Soot and PAH in coal liquid fuel furnace flames; pp 1205-1219.

(45) Lia Paalme et al; Reactivity of PAH in UV - and γ-radiation initiated oxidation reaction; pp 999-1008.

(46) J.E. Eldridge et al; PAH emissions from paving asphalt in laboratory simulation; pp 471-482.

(47) Alan B. Dash and P.M. Guldberg; A generalized model for estimating the concentration of PAH in urban air; pp 379-392.

(48) T. Nielsen et al; The presence of nitro PAH in samples of airborne particulate matter; pp 961-970.

(49) J.H. Miller et al; Optical studies of PAHs in pyrolysis and diffusion flame environments; pp 905-919.

(50) A.H. Miguel; Atmospheric reactivity of polycyclic aromatic hydrocarbons associated with aged urban aerosols; pp 897-904.

(51) Per Nielsen; PAH emissions from a 4.7MW coal fired fluidized bed plant; pp 951-959.

(52) J.B. Howard and J.P. Longwell; Formation mechanisms of PAH and soot in flames; pp 27-62.

(53) C.V. Knight et al; Polynuclear aromatic hydrocarbons and associated organic emissions for catalytic and non catalytic wood heaters; pp 689-710.

(54) J. Konig et al; Quinone and ketone derivatives of PAH in particulate matter from ambient air; pp 711-720.

(55) R.C. Lao et al; Investigation of PAH and polychlorinated organic pollutant emissions from wood combustion sources; pp 745-755.

(56) J. Jacob et al; Rat liver and lung miscosomal metabolism of benz(a) and benz(c) acridine; pp 637-647.

(57) J.W. Flesher et al; Metabolic activation of carcinogenic hydrocarbons in the meso-position. (L-Region); pp 505-515.

(58) R.F. Lee et al; Fate of polycyclic aromatic hydrocarbons in controlled ecosystem enclosures; pp 832-838; Environmental Science and Technology; Volume 12; No. 7; 1978.

(59) T. Ramdahl; Polycyclic Aromatic Ketones in environmental samples; Environmental Science and Technology; pp 666-670; vol. 14; 1983.

(60) M.M. Hughes et al; Chemical transformations of particulate polycyclic organic matter; pp 1-8; Polynuclear Aromatic Hydrocarbons; chemistry and biological effects; 4th International Symposium; 1979.

(61) H. Autrup et al; Metabolism of benzo(a) pyrene in cultured human branchus, trachea, colon and esophagus; pp 89-105; Polynuclear Aromatic Hydrocarbons; Chemistry and Biological Effects; 4th International Symposium, 1979.

(62) A. Greenberg et al; Analysis of polynuclear aromatic hydrocarbons on the airborne particulates of urban New Jersey; Polynuclear Aromatic Hydrocarbons; Chemistry and Biological Effects; 4th International Symposium; 1979; pp 193-198.

(63) J.W. Strand and A.W. Andren; Polyaromatic Hydrocarbons in aerosols over Lake Michigan fluxes to the lake; Polynuclear Aromatic Hydrocarbons; Chemical Analysis and Biological Fate; 5th International Symposium; held 1980 pp 127-137 (1981).

(64) G. Grimmer et al; Changes in PAH profiles in different areas of a city during the year. Polynuclear Aromatic Hydrocarbons; Chemical Analysis and Biological Fate; 5th International Symposium; held 1980. pp 107-125 (1981).

(65) Irving Salmeen et al; Identification and quantification of direct acting ames assay mutagen in diesel particulate extracts. Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurement; 7th International Symposium; held 1982; pp 1057-1066 (1983).

(66) P.A. Andrews et al; Metabolism of nitrated polycyclic aromatic hydrocarbons and formation of DNA adducts in salmonella typhimumium; Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurement; 7th International Symposium; held 1982; pp 89-98 (1983).

(67) E. Rogan, E. Cavalieri et al; Synergistic effect of the environmental contaminants cyclopenta (c,d) pyrene and benzo(a) pyrene in mouse skin carcinogenicity; Polynuclear Aromatic Hydrocarbons; Formation Metabolism and Measurement. 7th International Symposium; held 1982; pp 1035-1046 (1983).

(68) G. Grimmar et al; Analysis of the balance of carcinogenic impact from emission condensate of automobile exhaust by implantation into the lung of rats as a carcinogen specific detector. Polynuclear Aromatic Hydrocarbons; Formatism, Metabolism and Measurement; The 7th International Symposium; held 1982; pp 571-582. (1983).

(69) Eva Brorstrom et al; Transformation of polycyclic aromatic hydrocarbons during sampling in ambient air by exposure to different oxidized nitrogen compounds and ozone. Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurement; 7th International Symposium; held 1982. pp 201-210 (1983).

(70) M.A. Butler et al; Application of salmonella assay to carbon blacks and toners; Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurements; 7th International Symposium; held 1982; pp 225-241, (1983).

(71) T.L. Gibson et al; Measurement of polynuclear aromatic hydrocarbons theirderiatives and their reactivity in diesel automobile exhaust; Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurement; 7th International Symposium, held 1982; pp 707-717 (1983).

(72) F.S.C. Lee; W.R. Pierson and J. Ezike; The problem of PAH degradation during filter collection of automotive particulates - an evaluation of several commonly used filter media. Polynuclear Aromatic Hydrocarbons; Formation, Metabolism and Measurement; 7th International Symposium held 1982; pp 543-563 (1983).

(73) B.R. Hubble et al; Experimental measurements of emissions from residential wood burning stoves. Proceedings - International Conference on Residential Solid Fuels - Environmental Impacts and Solutions - held 1979; pp 79-138; published 1982, edited by J.A. Cooper, D. Malek.

(74) Lars Rudling et al; Chemical and Biological characterization of emissions from combustion of wood and wood chips in small furnaces and stoves; Porceedings - International Conference on Residential Solid Fuels, Environmental Impacts and Solutions; held 1981; pp 34-53 (1982), edited by D. Malek and J.A. Cooper.

(75) Frank Zimar et al; The effect of catalytic combustion on cresole reduction, combustion efficiency and pollution abatement for residential wood heaters. Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions - held 1982, pages 924-40 (1983). J.A. Cooper and D. Malek (editors).

(76) Olle Lindstrom; Gasification/Combustion of wood. Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions, held 1981; pp 789-807 (1983) D.A. Malek J.A. Cooper (editors)

(77) James F. Hornig et al; Ambient air assessment in rural village and small town locations in New Hampshire where wood is an important fuel. Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions; held 1982; pp 506-519 (1983) D. Malek and J.A. Cooper (editors).

(78) D.J. Murphy et al; Ambient particulate and benzo(a) pyrene concentrations from residential wood concentrations from residential wood combustion in a mountain resort community. Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions; held 1982; pp 495-505 (1983); D. Malek and J.A. Cooper (editors).

(79) J.A. Peters et al; Wood combustion emissions at elevated altitudes Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions; held 1982; pages 199-209 (1983); J.A. Cooper and D. Malek (editors).

(80) J. Lewtas; Comparison of the mutagenic and potentially carcinogenic activity of particle bound organics from wood stoves, residential oil furnaces and other combustion sources. Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions; held 1982; pp 267- (1983); J.A. Cooper and D. Malek (editors).

(81) J. Santodonato et al; Multimedia human exposure and carcinogenic risk assessment for environmental PAH; Polynuclear Aromatic Hydrocarbons; Chemistry and Biological Effects; 4th International Symposium pp 435-454 (1979).

(82) June H. Carver et al; Mutagenicity testing in mammalian cells; Mutation Research; 72; 207-230 (1980).

(83) Won-Zong Whong et al, life of improved arabinose resilant assay system of samonella typhimerium for mutagensis testing. Environmental Mutagensis 3(1), 95-9 (1981).

(84) G.S. Probst et al; Chemically induced DNA synthesis in primary rat hepatocycle cultures. A comparison with bacterial mutagenicity using 218 compounds. Evnironmental Mutagenesis; 3; 11-32 (1981).

(85) R.B. Painter and R. Howard; A comparison of the He La DNA Synthesis inhibition test and the Ames Test for screening of mutagenic carcinogens, Mutation Research; 54; 113-115 (1978).

(86) D.G. Gatehouse and G.F. Delow; The development of a microtitre flucuation test for the detection of indirect mutagens and its use in the evaluation of mixed enzyme induction of the liver; Mutation Research; 60; 239-252 (1979).

(87) A. Grafe et al; European collaborative study of the Ames assay; results and general interpretation, Mutation Research; 85; 391-410 (1981).

(88) NTIS Report: PB81-171142; Health hazard evaluation determination report no: HE-79-43-663. Harbinson Walker Refractories, Clearfield, Pennsylvania.

(89) NTIS Report: PB82-151176; Health Hazard evaluation report; HE-80-50-722; CI and I Steel Corporation; Pueblo; Colorado.

(90) NTIS Report: PB82-150210; Health hazard evaluation report: HE-78-44-715; Kaiser Aluminum and Chemical Corporation, Ravenswood; West Virginia, 26164.

(91) NTIS Report: PB82-184623; Industrial Hygiene Survey Report; Kaiser Aluminum and Chemical Corporation, Chalmette Works, Chalmette, Louisiana - 70044.

(92) NTIS Report: PB292520; Air Pollutant Emission Factors for military and civil aircraft.

(93) NTIS Report: PB291657: Health hazard evaluation determination report 77-56-467; Johns Manville Products Corporation; Pittsburgh, California.

(94) NTIS Report: PB82-150251; Health hazard evaluation determination report; Wheeling Pittsburgh Steel Corporation; Follansbee, West Virginia. October, 1980.

(95) NTIS Report: PB82-109414; Emissions assessment of conventional stationary combustion systems; summary report; September 1981.

(96) NTIS Report: PB81-113599; POM (Polycyclic Organic Matter) source and ambient concentration data: Review and analysis; March 1980.

(97) NTIS Report: PB83-109728; Pilot plant study of factors affecting polynuclear aromatic hydrocarbon emission from coke ovens.

(98) NTIS Report: DE83-901861; Measurement of POM emissions from coal fired utility boilers.

(99) NTIS Report: PB80-221948; Fate of toxic and hazardous materials in the air environment.

(100) NTIS Report: PB82-121336; Source resolution of polycyclic aromatic hydrocarbons in the Los Angeles atmosphere; application of a chemical species balance method with first order chemical decay; September 1981.

(101) S.S. Epstein et al; Carcinogenicity of a composite organic extract of urban particulate atmospheric pollutants following subutaneous injection in infant mice.

(102) J. Van Cantfort and J.E. Gielen; Ontogenetic variation in rat liver, lung and kidney mono oxygenase induction by low doses of benzo(a) pyrene and cigarette smoke condensate; British Journal of Cancer 44(6); 902-10 (1981).

(103) A. Gold, S. Nesnow et al; Mutagenesis and morphological transformation of mammalian cells by a non-bay region polycyclic cyclopenta (c,d) pyrene and its 3.4-oxide;

Cancer research; 40; 4482-4484; December 1980.

(104) G. Fiskesjo; Benzo(a) pyrene and N-methyl-N-Nitroso-N-Nitroguaridine in the Allium Test, Hereditas; 95(1); 155-162 (1981).

(105) Ilse Lasnitzki and Werner Bollag; Prevention and reversal by a retinoid of 3.4-benzpyrene and cigarette smoke condensate induced hyperplasia and metaplasia of rodent respiratory epithelia in organ culture; Cancer Treatment Reports; Vol. 66; pp 1375-1380 (1982).

(106) G.M. Davies; Measurement and analysis of airborne emissions from coke ovens with a particular reference to ~~cancer~~ worker exposures; Commission of the European Communities; EUR 7197; pp 75-95 (1981).

(107) F. Valero et al; Evaluation of the cancerogenic risk in oil tankers during refitting. Cancer Detection and Prevention; 5(3); 335-41 (1982).

(108) Wayne Westbrook; Ferroalloy Furnaces; generation and emission of particulate and organic matter. Electric Furnace Conference Proceedings: Vol. 39; pp 226-242 (1982).

(109) D.K. Verma et al; Polycyclic Aromatic Hydrocarbons in Ontario Foundry Environments; Annals of occupational hygiene; Vol 25; pp 17-25; 1982.

(110) R.V. Hendricks et al; Organic air emissions from coke quench towers; 72nd Annual Meeting of the Air Pollution Control Association; June 24-29 (1979).

(111) N.L. Nagda et al. Emission Factors and emission inventories for carcinogenic substances; 72nd Annual Meeting of the Air Pollution Control Association; June 24-29 (1979) pp 79-3:1

(112) V. Friedrich and G. Nass; Evaluation of a mutation test using S49 mouse lymphoma cells and monitoring simultaneously the induction of dexamethasone resistance; 6-thioguanine resistance and ouabain resistance; Mutation Research; 110(1), 147-62 (1982).

(113) Mona Moller et al; Mutagenicity of extracts from typewriter ribbons and related items; Mutation Research; 119(3-4); pp 239-249 (1983).

(114) D.A. Haugen and M.J. Peak; Mixtures of polycyclic aromatic compounds inhibit mutagenesis in the salmonella microsome assay by inhibition of metabolic activation; Mutation Research; 116(3-4) 257-269 (1983).

(115) R.B. Painter and Ricci Howard; The He La DNA Synthesis inhibition test as a rapid screen for mutagenic carcinogens, Mutation Research; 92; pp 427-37 (1982).

(116) J.M. Walters and R.D. Combes; Evaluation of a methodology for the use of preparations from rat small intestine in the salmonella microsome assay. Mutation Research; 113(5) 393-402 (1983).

(117) R.J. Cole et al; Short-term test for transplacentally active carcinogens; a Comparison of sister chromalid exchange and the micronucleas test in mouse fetal liver erythroblasts; Mutation Research; 113(17) 61-75 (1983).

(118) Silvio Parodi et al; Quantitative correlations amongst alkaline DNA fragmentation; DNA covalent binding, mutagenicity in the Ames Test and carcinogenicity for 21 compounds; Mutation Research; 93, 1-24 (1982).

(119) A. Blank et al; Biothansformations of benzo(a) pyrene and 7-ethoxyresorufin and heme-staining proteins in microsomes from human fetal liver and placenta; Biochemical Pharmacology; 32(10); 1547-52 (1983).

(120) J.A. Bond, C.E. Mitchell and A.P. Li; Metabolism and micro molecular covalent binding of B(a)P in cultured Fischer - 344 rat lung type II epithelial cells. Biochemical Pharmacology; Vol 32; No. 24; pp 3771-3776 (1983).

(121) A.P. Li et al; Comparative mutagenicity of a coal combustion fly ash extract in salmonella typhimunum and chinese hamster ovary cells; Environmental Mutagensis; Vol. 5; pp 263-272 (1983).

(122) H.L. Gurtoo et al; Population distribution of placental benzo(a) pyrene metabolism in smokers. International Journal of Cancer; 31; pp 29-37 (1983).

(123) E. Cavalieri et al; Syncarcinogenic effect of the environmental pollutants cyclopenteno(cd) pyrene and benzo(a) pyrene in mouse skin carcinogenis, Vol 44; pp 393-397 (1983).

(124) T. Shen; Estimation of organic compound emissions from waste lagoons. Journal of Air Pollution Control Association; 32(1); pp 79-71 (1982).

(125) G.A. Eiceman and V.J. Vandiver; Adsorption of polycyclic aromatic hydrocarbons on fly ash from a municipal incinerator and a coal fired power plant.

Atmospheric Environment; 17(3); pp 461-465 (1983).

(126) T. Ramdahl et al; Chemical and biological characterization of emissions from small residential stoves burning wood and charcoal; Chemosphere; 11(6); 601-11 (1982).

(127) C.Y. Wang et al; Evidence for nitroaromatics as direct acting mutagens of airborne particulates Chemosphere; Vol 9(2); pp 83-87 (1980).

(128) A.A. Bradley et al; Polynuclear aromatic hydrocarbons in the condensed phases associated with coal gasification gas cleaning pilot plant; Polynuclear Aromatic Hydrocarbons; Formation, metabolism and measurement; 7th International Symposium; held 1982; pp 147-166 (1983) Battelle Press.

(129) W.M. Cook et al; Characterization of emissions from residential wood combustion sources; Proceedings - International Conference on Residential Solid Fuels - Environmental Impacts and Solutions; held 1982; pages 139 - (1983) J.A. Cooper and D. Malek (editors).

(130) T.W. Hughes and D.G. DeAngelis; Emissions from coal fired residential combustion equipment; Proceedings - International Conference on Residential Solid Fuels; Environmental Impacts and Solutions; held 1982; pp 333-348 (1983) J.A. Cooper and D. Malek (editors).

(131) K.McMahon et al; Combustion characteristics and emissions from burning organic soils; 73rd Annual Meeting of the Air Pollution Control Association; June 22-27; 1980; pp 80-15.5.

(132) D.E. Amacher et al; Point mutations at the thymidine kinase loeus in L5178Y mouse lymphomen cells; test validation and interpretation Mutation Research; Vol. 72; pp 447-74 (1980).

(133) E. Cavalieri et al; Syncarcinogenic effect of the environmental pollutants cyclopenteno (c,d) pyrene and benzo(a) pyrene in mouse skin; carcinogensis; vol. 4(4); pp 393-397 (1983).

(134) J. Jacob; Analysis of metabolites of polycyclic aromatic hydrocarbons by GC and GC/MS; Handbook of Polycyclic Aromatic Hydrocarbons; edited by Alf Bjorseth; Marcel Dekker Inc.

(135) J. Jacob, et al; Rat liver and lung microsomal metabolism of benz(a) and benz(c) acridine; Polynuclear aromatic hydrocarbons - chemical analysis and biological fate; 5th International Symposium; held 1980; published 1981; pages 637-647.

(136) CESARS Data Base; Chemical Information System; Dibenz(a,h) anthracene, Phenanthrene; Chrysene, Anthracene.

(137) Toxicology Data Bank; Data Base; National Library of Medicine.